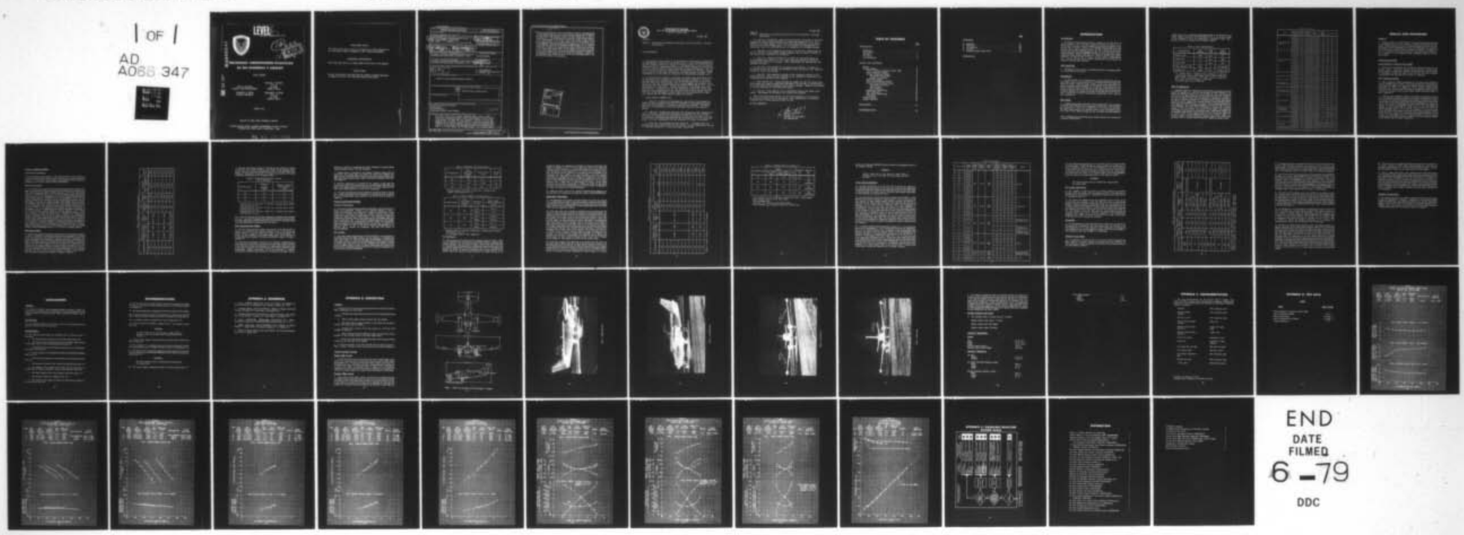
AD-A068 347 ARMY AVIATION ENGINEERING FLIGHT ACTIVITY EDWARDS AF--ETC F/G 1/3
PRELIMINARY AIRWORTHINESS EVALUATION RU-21H GUARDRAIL V AIRCRAF--ETC(U)
MAR 78 J R NIEMANN, R B SMITH, W A NORTON

UNCLASSIFIED USAAEFA-77-11 NL

1 OF 1
AD
A068 347



END
DATE
FILMED
6-79
DDC

LEVEL II

SB

USAAEFA PROJECT NO. 77-19

PRELIMINARY AIRWORTHINESS EVALUATION

RU-21H GUARDRAIL V AIRCRAFT

FINAL REPORT

JOHN R. NIEMANN
PROJECT OFFICER/ENGINEER

RAYMOND B. SMITH
PROJECT ENGINEER

WILLIAM A. NORTON
CPT, IN
US ARMY
PROJECT PILOT

FREDERICK S. DOTEN
MAJ, IN
US ARMY
PROJECT PILOT

MARCH 1978

Approved for public release; distribution unlimited.

UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

DISCLAIMER NOTICE

DISPOSITION INSTRUCTIONS

TRADE NAMES

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
USAAEFA PROJECT NO. 77-19

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
(6) PRELIMINARY AIRWORTHINESS EVALUATION RU-21H GUARDRAIL V AIRCRAFT.

5. TYPE OF REPORT & PERIOD COVERED
(9) FINAL REPORT.
14 - 27 October 1977

6. PERFORMING ORG. REPORT NUMBER
USAAEFA PROJECT NO. 77-11

7. AUTHOR(s)
(10) JOHN R. NIEMANN, ~~CPT~~ WILLIAM A. NORTON
RAYMOND B. SMITH, ~~MAJ~~ FREDERICK S. DOTEN

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
US ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
EJ7Z071800EJEJ

11. CONTROLLING OFFICE NAME AND ADDRESS
US ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

12. REPORT DATE
(11) MARCH 1978

13. NUMBER OF PAGES
50

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
(12) 52 p.

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
NA

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(14) USAAEFA-77-11, USAAEFA-77-19

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Preliminary airworthiness evaluation
Flying qualities
RU-21H Guardrail V
Single-engine minimum control airspeed

V sub MC

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted a Preliminary Airworthiness Evaluation of the RU-21H Guardrail V (GR V) aircraft flying qualities. The flight tests were conducted at Edwards Air Force Base, California, from 14 through 27 October 1977 for a total of 9.3 productive flight hours. The RU-21H (GR V) exhibited 1 deficiency and 10 shortcomings which will degrade its overall capability. The single-engine minimum-control airspeeds (V_{MC}) were 5 to 10 knots greater than the data provided in the operator's manual. → over

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 409 025 slt

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

V sub MC

The incorrect V_{MC} data presented in the operator's manual are a deficiency which warrants further testing and, as an interim measure, requires that a WARNING be incorporated in the operator's manual. Ten shortcomings listed in order of importance, are (1) The dissimilar sense of operation of the attitude indicators; (2) the excessive glare in the cockpit caused by the navigation lights mounted on the upper surfaces of the external wing-tip pods; (3) the inaudibility of the stall warning horn when wearing helmet and oxygen mask; (4) the low intensity of the MASTER CAUTION and MASTER WARNING lights; (5) the inefficient arrangement of navigation and communications radios; (6) the premature activation of the artificial stall warning device; (7) the inability to shut down the engine by use of the condition lever; (8) the lightly damped, easily excited phugoid; (9) the ineffective lateral trim; and (10) the excessive force required to operate the radio/intercom switch. Within the scope of this test, the flying qualities of the RU-2H (GR V) aircraft are acceptable.

DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
P O BOX 209, ST. LOUIS, MO 63166

22 DEC 1978

DRDAV-EQ

SUBJECT: Preliminary Airworthiness Evaluation, RU-21H Guardrail V Aircraft Final Report

SEE DISTRIBUTION

1. The purpose of this letter is to establish the Directorate of Development and Engineering's position on the subject report. While MIL-F-8785B(ASG) was used as a guide by AEFA for purposes of flying qualities, it must be clearly understood that no requirement exists for the RU-21H Guardrail V specifically, or any of the U-21 series to meet requisites of this specification. The U-21 and all its derivatives were procured as off-the-shelf air vehicles, meeting the requisites of FAA type certification as Normal Category Airplane. These comparisons to the MIL SPEC are therefore for informational purposes only.

2. In the process of trying to track down the dynamic Vme differences noted in the report, (see paragraph 25) we have detected an anomaly in criteria. The FARs specify no control delay time, MIL-F-8785B specifies a one second delay if other cues (acceleration, rate or displacement) are available, and the US Navy Test Pilot School Flight Test Manual (USNTPS-FTM No 103, 1 Jan 75) recommends one second delay. For this evaluation, a two second delay time was utilized. It appears that the most meaningful criteria for future tests would be a one second delay, to be consistent with military design criteria. With the current difference in delay time it is not surprising that these test results and the flight manual presentation differ.

3. Other specific comments are:

a. Para 44 - Information concerning Vmc corrections to the Operator's Manual has been included in the Interim Statement of Airworthiness Qualification (a copy of which is included in each aircraft logbook). Corrected data will be incorporated in the next published change to the Operator's Manual.

b. Para 45a - Operational units have been flying this same configuration (RU-21 A/B/C/E/H) for many years and have not reported this as a problem. Since the two instruments are sufficiently removed from each other so as not to constitute a possible disorientation due to observation of both simultaneously, it is not considered to be cost effective to correct the problem.

c. Para 45b - This problem has been corrected. A shielded cover was developed for this configuration for the RU-21A. It was inadvertantly omitted for the AEFA evaluation. It has since been incorporated.

22 DEC 1978

DRDAV-EQ
SUBJECT: Preliminary Airworthiness Evaluation, RU-21H Guardrail V Aircraft Final Report

d. Para 45c - Operational units have reported that activation of the stall warning horn during mission profiles is distracting because it is too loud. Therefore, at their request, the aircraft have been modified to allow deactivation of the system during cruise. It can therefore be concluded that in operational use it is sufficiently loud to accomplish it's intended purpose.

e. Para 45d - This problem is not unique to the RU-21H. Though state of the art systems can now provide sunlight readable caution lights, retrofit of the fleet is not considered cost effective.

f. Para 45e - Complete redesign of a cockpit for each modification is not considered cost effective. As a result when new systems are added the optimum space available is utilized. Hence compromises are required when new equipment is added.

g. Para 45f - This problem is not unique to the RU-21H. It exists on all series of the U-21 and was not considered within the scope of the Guardrail program to correct the problem.

h. Para 45g - This problem is unique to test technique utilized in the AEFA evaluation. Since the test technique is not repeated in operational use correction of the problem is not required.

i. Para 45h and 45 i - These problems are common the the U-21 series fleet. Corrections would require significant redesign of the aircraft or incorporation of an artificial device (Automatic Flight Control System). Neither is considered to be cost effective for the Guardrail program.

j. Para 45j - This appears to be a maintenance rather than design shortcoming. Replacement of the switch will correct this problem.

4. Since the flight characteristic of the RU-21H (Guardrail V) are similar to other U-21 aircraft and are acceptable, this configuration is considered airworthy from a flying qualities point of view.

FOR THE COMMANDER:

WALTER A. RATCLIFF
Colonel, GS
Director of Development
and Engineering

TABLE OF CONTENTS

Page

APPENDIXES

DISTRIBUTION

INTRODUCTION

BACKGROUND

1. The Beech Aircraft Corporation (BAC) is modifying 27 RU-21H aircraft to accept Guardrail V (GR V) mission equipment. The primary mission of the RU-21H (GR V) aircraft is radio reconnaissance. The exterior configuration of the RU-21H (GR V) aircraft is similar to the CEFIRM LEADER (RU-21A) range extension aircraft with its wing-tip antennas. The GR V aircraft also has mission antenna arrays and flare/chaff dispensers. In May 1977, the United States Army Aviation Systems Command (AVSCOM)* directed the United States Army Aviation Engineering Flight Activity (USAAEFA) to conduct a limited flying qualities evaluation of an RU-21H (GR V) aircraft at the BAC facility in Wichita, Kansas (ref 1, app A). However, due to weather considerations the test location was changed to Edwards AFB, California.

TEST OBJECTIVE

2. The objective of this test was to qualitatively evaluate the handling qualities of the RU-21H (GR V) aircraft.

DESCRIPTION

3. The RU-21H (GR V) is an unpressurized, low wing, 10,200-pound maximum gross weight, all-metal aircraft powered by two T74-CP-700 turboprop engines. The aircraft has slender streamlined engine nacelles, wing-tip pods, square-tipped tail surfaces, swept-back vertical stabilizer, and a ventral fin. The aircraft also has two XM-130 flare/chaff dispensers installed on the right side. Cabin entrance is made through a stair-type door on the left side of the fuselage. Shock-mounted racks for special equipment are installed on the cabin. Further description of the RU-21H (GR V) aircraft may be found in the operator's manuals (refs 2 and 3, app A), and in appendix B.

TEST SCOPE

4. A limited flying qualities evaluation of the RU-21H (GR V) was conducted at Edwards AFB, California, from 14 through 27 October 1977. Five test flights were conducted for a total of 12.2 flight hours, 9.3 of which were productive. The flight envelope limits of the operator's manual and the airworthiness release (ref 4, app A) were observed during this test. An engine start gross weight of

*Since redesignated the United States Army Aviation Research and Development Command (AVRADCOM)

-10,400 pounds and a maximum takeoff gross weight of 10,300 pounds were utilized. Military specification MIL-F-8785B(ASG) (ref 5) was used as a guide for this evaluation. A list of test configurations is presented in table 1 and a summary of the test conditions flown is shown in table 2.

Table 1. Test Configurations.

Configuration	Gear Position	Flaps (%)	Power Setting
Takeoff (TO)	Down	Zero	TO[1]
Climb (CL)	Up	Zero	NRP[2]
Cruise (CR)	Up	Zero	PLF[3]
Power approach (PA)	Down	35	As required
Landing (L)	Down	100	Flight-idle[4]

[1]TO: Takeoff power - maximum torque allowable at 2200 rpm. (Interstage turbine temperature and N_1 limits observed.)
[2]NRP: Normal rated power - 1284 ft/lb torque at 2000 rpm.
[3]PLF: Power for level flight at 1900 rpm.
[4]Propeller speed set at 2200 rpm.

TEST METHODOLOGY

5. Established flight test techniques and data reduction procedures were used during this program (ref 6, app A). Test methods are briefly described in the Results and Discussion section of this report. Flight test data were recorded by hand from normal flight instruments and special test instrumentation installed at the pilot and copilot stations. Test instrumentation is described in appendix C. Test data are presented in appendix D. A Handling Qualities Rating Scale (HQRS) (app E) was used to augment pilot comments relative to aircraft handling qualities. Deficiencies and shortcomings are in accordance with the definitions presented in Army Regulation 70-10. An airspeed calibration of the RU-21H (GR V) aircraft was conducted on 20 October 1977 by USAAEFA at Edwards AFB, California, utilizing a T-28 pace aircraft. The aircraft takeoff weight and longitudinal center-of-gravity (cg) location were determined prior to flight testing. Weighing was accomplished using electronic scales located under the aircraft jack points with the crew on board at their designated stations. All test condition weights were calculated utilizing a calibrated cockpit fuel quantity indicator. The aircraft cg was determined from a "cg shift with fuel burn-off" diagram provided by BAC.

Table 2. Test Conditions.

Test	Density Altitude (ft)	Outside Air Temperature (°C)	Gross Weight (lb)	Center of Gravity (FS)	Trim Calibrated Airspeed (kt)	Configuration
Static longitudinal stability	10,500	1.0	9460	152.3 (fwd)	120	PA
	10,400	-1.0	9300	152.2 (fwd)	140	CR
	10,800	0.5	9140	151.9 (fwd)	170	CR
	10,600	1.0	9640	158.1 (aft)	120	PA
	10,400	4.0	9740	158.1 (aft)	140	CR
	10,100	6.0	9460	157.9 (aft)	170	CR
Dynamic longitudinal stability	23,500	-14.0	9160	151.9 (fwd)	110	CR
	10,400	0.0	9570	152.4 (fwd)	120	PA
	10,400	0.5	9880	152.6 (fwd)	140	CR
	10,200	3.0	10,000	152.6 (fwd)	170	CR
	10,700	-1.0	9400	152.3 (fwd)	140	CR
	10,600	0.0	9240	152.1 (fwd)	170	CR
	10,400	1.0	8800	157.0 (aft)	120	PA
	10,500	2.0	8750	156.8 (aft)	140	CR
	10,600	3.5	8640	157.0 (aft)	170	CR
Maneuvering stability	11,000	-2.0	9020	157.4 (aft)	120	PA
	10,200	2.0	9300	157.8 (aft)	140	CR
	10,000	3.0	9240	157.7 (aft)	170	CR
Static lateral-directional stability	10,200	2.0	9400	157.9 (aft)	120	PA
	9500	7.0	9190	157.6 (aft)	140	CR
	10,100	4.0	9620	158.1 (aft)	170	CR
Dynamic lateral-directional stability	10,300	1.5	9240	157.7 (aft)	120	PA
	10,100	5.0	9130	157.6 (aft)	140	CR
	9800	5.0	9520	158.0 (aft)	170	CR
Roll performance	23,500	-14.0	9300	152.2 (fwd)	110	CR
	10,200	7.0	9900	152.6 (fwd)	120	PA
	10,200	2.0	9180	157.5 (aft)	120	PA
	10,100	5.0	9130	157.6 (aft)	140	CR
	10,000	5.0	9460	157.7 (aft)	170	CR
Single-engine characteristics	10,100	3.0	10,060	158.2 (aft)	---	TO, PA, L, CR
	10,600	8.0	9460	152.3 (fwd)	---	PA, L
	10,000	4.0	9600	158.1 (aft)	---	CR, TO, PA, L
Stall characteristics	10,100	1.0	9720	152.5 (fwd)	---	CR, PA
	23,500	-14.0	9080	151.8 (fwd)	---	CR
	10,700	8.0	10,100	152.6 (fwd)	---	PA
Trim changes	11,000	7.0	9020	157.4 (aft)	120, 140, 170	PA, CR, TO
	10,500	1.5	9840	152.5 (fwd)	120, 140, 170	TO, PA, CR
Airspeed calibration	9900	2.0	9900	158.2 (aft)	90 to 170	CR, PA

RESULTS AND DISCUSSION

GENERAL

6. Handling qualities of the RU-21H (GR V) aircraft were qualitatively evaluated at both forward and aft cg's with emphasis on operation near the maximum gross weight (10,200 pounds) at an aft cg. Comments regarding compliance with the requirements of MIL-F-8785B(ASG) are made where appropriate. The deficiencies and shortcomings identified during this program are tabulated in paragraphs 44 and 45 of this report. During this program two operator's manuals, references 2 and 3, appendix A, were consulted. A single consolidated operator's manual is recommended.

HANDLING QUALITIES

Control Positions in Trimmed Forward Flight

7. Flight control characteristics were qualitatively evaluated throughout the test program. Figure 1, appendix D, presents control positions in forward flight. Control positions were acceptable throughout the airspeed range tested and showed no abnormalities. Within the scope of this test, the trim control position characteristics of the RU-21H (GR V) aircraft are satisfactory.

Static Longitudinal Stability

8. Static longitudinal stability characteristics of the aircraft were evaluated at the test conditions shown in table 2. The aircraft was trimmed in steady-heading, ball-centered level flight at the desired trim airspeed. Without changing power or retrimming, the aircraft was stabilized in 5-knot indicated airspeed (KIAS) increments above and below the trim airspeed. Longitudinal control forces and positions were recorded at each test point and the results are presented in figures 2 and 3, appendix D.

9. Stick-free static longitudinal stability, as indicated by the variation of control force with airspeed, was positive in both the CR and PA configurations at forward and aft cg's. The stick-fixed longitudinal static stability, as indicated by elevator control position with airspeed, was positive in the CR configuration at both forward and aft cg's. In the PA configuration stick-fixed longitudinal static stability was positive at a forward cg but essentially neutral at an aft cg. The static longitudinal stability of the RU-21H (GR V) aircraft did not meet the criteria of MIL-F-8785B(ASG) (para 3.2.1.1) in the PA configuration at an aft cg, in that a more aft position of the elevator control was not required to maintain an airspeed slower than trim. However, the near-neutral control position gradients at an aft cg were not objectionable due to the positive elevator force cues of airspeed variation from trim. Within the scope of this test, the static longitudinal stability of the RU-21H (GR V) aircraft is satisfactory.

Dynamic Longitudinal Stability

Short-Period Characteristics:

10. The short-period characteristics of the RU-21H (GR V) were evaluated by exciting the aircraft with an elevator control doublet input and noting the aircraft response. The short-period characteristics of the RU-21H (GR V) aircraft are satisfactory and meet the criteria of MIL-F-8785B(ASG).

Phugoid Characteristics:

11. The phugoid mode was evaluated by trimming the aircraft for hands-off level flight at the desired trim airspeed, stabilizing at 10 KIAS below this airspeed, and then slowly releasing the elevator control, allowing it to seek trim. The phugoid response of the RU-21H (GR V) at an aft cg was oscillatory, lightly damped, and easily excited in the CR configuration at 170 knots calibrated airspeed (KCAS) and neutrally damped at 140 KCAS. In the PA configuration at an aft cg the phugoid oscillations were divergent; however, during landing approach with the pilot tightly in the loop, the negative damping of the phugoid was not a problem. The phugoid oscillations at a forward cg were lightly damped, and easily excited in all configurations. The phugoid frequency and damping characteristics are presented in table 3. The long period, low damping, and ease of excitement of the phugoid in the CR configuration made long-term longitudinal trimmability of the aircraft difficult to achieve (HQRS 6). Airspeed variations of 3 to 5 KIAS were common in all flight regimes. During the high-altitude evaluation of the aircraft (22,000 feet pressure altitude (Hp), 110 KIAS, CR configuration), excessive pilot attention was required to maintain airspeed and altitude. The lightly damped, easily excited phugoid characteristics of the RU-21H (GR V) aircraft are a shortcoming. Because of the unsatisfactory phugoid characteristics, the installation of an autopilot is considered essential to reduce pilot workload and fatigue on long missions. At an aft cg, at trim airspeeds of 140 KIAS and below, the aircraft phugoid characteristics in the PA and CR configurations did not meet the damping criteria of MIL-F-8785B(ASG) (para 3.2.1.2) for level 1 handling qualities.

Maneuvering Stability

12. Maneuvering stability characteristics were evaluated at the conditions presented in table 2. In addition, an abbreviated evaluation was accomplished at 110 KIAS in the CR configuration. The variation of elevator control force and position with normal acceleration was determined by trimming the aircraft in coordinated level flight at the desired airspeed and configuration and then stabilizing in coordinated flight at incremental bank angles in both left and right turns. Airspeed was held constant and the aircraft allowed to descend during the maneuver. Data were obtained at each stabilized bank angle. Symmetrical pull-up and pushover maneuvers were also conducted. Load factor was varied incrementally to the maximum allowable. The results of the maneuvering stability evaluation for the RU-21H (GR V) aircraft are presented in figures 4 through 6, appendix D.

Table 3. Phugoid Mode Characteristics.

Configuration	Density Altitude (ft)	Gross Weight (lb)	Center of Gravity (FS)	Trim Calibrated Airspeed (kt)	Damping Ratio (ζP)	Undamped Natural Frequency (ωn ~ rad/sec)	Period (sec)
PA	11,000	8700	157.0 (aft)	118	-0.08	0.131	48.0
CR				140	0.0	0.127	49.5
CR				170	0.07	0.105	30.0
PA	10,400	9800	152.5 (fwd)	119	0.06	0.141	44.5
CR				140	0.06	0.141	44.5
CR				170	0.09	0.129	49.0
CR	23,500	9200	151.9 (fwd)	109	0.05	0.146	43.0

13. Stick-free maneuvering stability, as indicated by the variation of elevator control force with normal acceleration, was positive for all conditions tested. Elevator control force gradients are summarized in table 4. Stick-fixed maneuvering stability, as indicated by the variation of elevator control position with normal acceleration, was positive for the conditions tested.

Table 4. Maneuvering Stability Control Force Gradients.

Configuration	Calibrated Trim Airspeed (kt)	Elevator Control Force Gradient (lb/g)
PA[1]	120	30
CR[2]	140	40
CR[3]	170	40

[1]Average density altitude: 11,000 feet. Average gross weight: 9020 pounds, aft cg.
[2]Average density altitude: 10,200 feet. Average gross weight: 9300 pounds, aft cg.
[3]Average density altitude: 10,000 feet. Average gross weight: 9240 pounds, aft cg.

14. At the test airspeeds for the CR configuration, buffeting was encountered from .2 to .5g prior to reaching the flight envelope limit. Buffet provided excellent cues when approaching aircraft limit load factor. Control forces were high enough to prevent inadvertently exceeding the limit load factor.

Static Lateral-Directional Stability

15. The static lateral-directional stability characteristics of the RU-21H (GR V) aircraft were evaluated at the conditions presented in table 2. The aircraft was initially trimmed in wings-level, ball-centered flight at the desired airspeed. The aircraft was then stabilized at incremental sideslip angles in both directions at constant airspeed and heading. Test results are presented in figures 7 through 9, appendix D.

16. Static directional stability, as indicated by the variation of sideslip angle with rudder pedal force and position, was positive up to full rudder deflection sideslips in both directions. Rudder force gradients were slightly greater than those found in previous U-21 flight tests, but were satisfactory. In the PA configuration during steady-heading sideslips approaching full rudder deflection, a relatively low-frequency divergent Dutch roll occurred. This oscillation, although a nuisance,

presented no problem in controlling the aircraft. Relaxation of rudder pressure caused immediate recovery from this oscillation.

17. Dihedral effect, as indicated by the variation of aileron control force and displacement with sideslip angle, was positive. The aileron force gradients were slightly greater and provided better force cues than those found on previous U-21 flight tests. Small heading changes in flight were easily accomplished using rudder only (HQRS 2).

18. Side-force characteristics, as indicated by the variation of bank angle with sideslip, were positive and provided good cues of uncoordinated flight. The bank angle versus sideslip gradients for the RU-21H (GR V) aircraft were greater than those found during previous U-21 tests and are satisfactory.

19. The static lateral-directional flying qualities of the RU-21H (GR V) aircraft show a slight improvement over the standard U-21A. Within the scope of this test the static lateral-directional flying qualities of the RU-21H (GR V) aircraft are satisfactory.

Dynamic Lateral-Directional Stability

Dutch-Roll Characteristics:

20. The dynamic lateral-directional stability characteristics of the RU-21H (GR V) aircraft were qualitatively evaluated at the conditions presented in table 2. Dutch-roll characteristics were evaluated by exciting the aircraft with a rudder doublet from a coordinated level flight trim condition. The Dutch roll was easily excited and tended to damp in approximately 2 cycles, regardless of airspeed or configuration. Estimated values of the period and the roll-to-sideslip angle (ϕ/β) ratio are presented in table 5. The Dutch-roll oscillation appeared to have a slightly higher roll-to-sideslip ratio, approximately the same period, and a significantly increased damping ratio (approximately double) over that found on previous U-21 flight tests. Within the scope of this test the Dutch-roll characteristics of the RU-21H (GR V) aircraft are satisfactory and meet the criteria of MIL-F-8785B(ASG).

Spiral Stability:

21. The spiral stability characteristics of the RU-21H (GR V) were evaluated by establishing trimmed level flight conditions and then stabilizing in a 10-degree bank angle, using rudders only. After the bank angle was established, the rudder pedals were slowly returned to neutral and the resulting tendency of the aircraft to increase or decrease bank angle noted. For all test conditions spiral stability was either neutral or slightly positive, as shown in table 6. Within the scope of this test the spiral stability characteristics of the RU-21H (GR V) aircraft are satisfactory and meet the criteria of MIL-F-8785B(ASG).

Table 5. Dutch-Roll Characteristics.[1]

Configuration	Trim Indicated Airspeed (kt)	Roll to Yaw (ϕ/β)	Period (sec)
PA	120	1.5/1	4
CR	140	1.75/1	3.8
CR	170	2/1	3.6

[1]Average density altitude: 10,000 feet. Average gross weight: 9250 pounds, aft cg.

Table 6. Spiral Stability Characteristics.[1]

Configuration	Trim Indicated Airspeed (kt)	Direction of Turn	Time to Half or Double Amplitude (sec)
PA	120	Left	19.6 C[2]
		Right	> 20
CR	140	Left	Neutral
		Right	Neutral
CR	170	Left	14.5 C
		Right	Neutral

[1]Average density altitude: 10,000 feet. Average gross weight: 9250 pounds, aft cg.
[2]C: Convergent time to half amplitude.

Roll Performance:

22. Roll performance was evaluated at the conditions presented in table 2. These tests were initiated from a trimmed unaccelerated flight condition by applying rapid one-half deflection and full deflection aileron control step inputs (less than 0.2 second) without changing elevator or rudder pedal control position. The aircraft was trimmed wings-level at the desired airspeed, then rolled to a 30-degree angle opposite the desired roll direction. Immediately prior to the roll input, the aft elevator control was relaxed to bring the aircraft to 1g flight. The time to roll

through 60 degrees was measured from initiation of aileron control input. Test results are presented in table 7. The roll mode time constant was qualitatively evaluated and there appears to be no discernible change from previous U-21 tests. Very little adverse yaw was generated (4 to 5 degrees) for full deflection aileron rolls. The Dutch roll was excited but its presence was barely perceptible in the steady-state roll. The oscillation was more noticeable at the lower airspeeds (120 KIAS, PA configuration, and 110 KIAS, CR configuration). At the higher airspeed (CR configuration, 140 and 170 KIAS) no oscillation was noted. Aileron force to obtain full deflection aileron inputs was approximately 65 to 70 pounds transient, with a steady state of approximately 50 pounds. Several evasive maneuvers were performed satisfactorily at 10,000 and 22,000 feet Hp. Within the scope of this test, the roll performance of the RU-21H (GR V) is satisfactory and meets the requirements of MIL-F-8785B(ASG).

23. Within the scope of this test, the dynamic lateral-directional stability of the RU-21H (GR V) is satisfactory and meets the criteria of MIL-F-8785B(ASG).

Single-Engine Characteristics

24. The single-engine characteristics of the RU-21H (GR V) aircraft were evaluated at the conditions shown in table 2. The static airspeed for minimum control (V_{MC}) was determined for both wings-level flight and for a 5-degree bank into the operating engine. Dynamic V_{MC} was determined for a left (critical) engine failure. The results of this test are presented in table 8.

25. Static V_{MC} tests were conducted by shutting down and feathering the left engine and then decelerating the aircraft in wings-level, constant-heading flight. The airspeed at which maximum lateral or directional control deflection was reached and heading or bank angle could not be maintained was defined as static V_{MC} (wings level). The controls were then relaxed, the airplane banked 5 degrees into the right engine, and again decelerated at constant bank angle in constant-heading flight. The airspeed at which maximum lateral or directional control deflection was reached and heading or bank angle could not be maintained was defined as static V_{MC} (5 degree bank angle). Dynamic V_{MC} tests were conducted by stabilizing at the desired configuration at a given airspeed and simulating a left engine failure (reducing power to idle). After power reduction, the controls were fixed for 2 seconds or until the aircraft yawed 20 degrees or rolled 30 degrees and then recovery, to the given airspeed in 5-degree bank angle flight, was completed. This procedure was repeated at incrementally lower airspeeds until an airspeed was reached where the pilot considered further reduction would result in marginal control (HQRS 6). This airspeed was defined as the dynamic V_{MC}.

26. Static V_{MC} (5-degree bank angle) data were compared with the data in the operator's manual. The test data do not agree with the operator's manual in the TO configuration. Based on test data, the values of V_{MC} presented in the operator's manual of the RU-21H (GR V) aircraft are incorrect and are a deficiency. Further testing should be conducted to determine dynamic V_{MC} for the RU-21-H (GR V) aircraft as a function of altitude, configuration, and gross weight. As an interim

Table 7. Roll Performance.

Configuration	Density Altitude (ft)	Gross Weight (lb)	Center of Gravity (FS)	Trim Indicated Airspeed (kt)	Aileron Control Deflection[1]		Roll Direction
					Half	Full	
PA	10,200	9300	157.7 (aft)	120	-	2.5	Left
PA				120	3.0	1.8	Right
CR				140	4.0	2.1	Left
CR				140	3.2	1.9	Right
CR				170	3.1	1.7	Left
CR				170	3.0	1.8	Right
CR				110	4.9	2.6	Left
CR				110	4.2	2.2	Right
PA	10,200	9900	152.6 (fwd)	120	4.3	-	Left
PA				120	3.4	-	Right
CR	23,500	9300	152.2 (fwd)	110	4.2	2.0	Left
CR				110	3.6	2.0	Right

[1]Time in seconds required to roll 60 degrees.

Table 8. Minimum-Control Airspeed.[1,2]

Configuration	Static			Dynamic V_{MC}	Handbook V_{MC}
	Full Rudder Trim	Full Rudder, Wings level	V_{MC}[3]		
TO	98	90	80	85	75
CL	98	91	74	--	Not available
PA	94	88	73	80[4]	Not available
L	110	85	72	82[4]	Not available

[1]Test conditions were 10,000 feet density altitude, 10,000 pounds gross weight, and cg at FS 158.2 (aft)

[2]All airspeeds KIAS.

[3]5-degree roll angle into operating engine.

[4]These dynamic V_{MC} airspeeds checked at forward cg.

measure, the following WARNING should be placed in the appropriate section of the operator's manual.

WARNING

> Aircraft control may be lost during an engine failure at airspeeds as much as 10 KIAS above those determined from the chart.

STALL CHARACTERISTICS

27. The stall characteristics of the RU-21H (GR V) aircraft were evaluated at the conditions presented in table 2. The evaluation included dual and single-engine unaccelerated stalls and accelerated dual-engine stalls at both forward and aft cg's. A stall was defined by either a pitch or roll break. Stall warning, initial buffet, and stall airspeeds are presented in table 9.

28. For all 1g stalls the aircraft was trimmed in straight and level flight at 1.5 stall airspeed (V_S) and then decelerated at approximately 1 knot per second until the stall occurred. All flight controls remained effective throughout the approach to stall. Stall recovery was immediate and positive with rudder opposite the turn and relaxation of the elevator control. Accelerated stalls were accomplished in 30 degree-bank left and right turns. The aircraft was again decelerated at approximately 1 knot per second until stall. Stall recovery was essentially the same as that required for the 1g stalls. Stall recovery from a right-turn accelerated stall was more easily accomplished because the aircraft characteristically rolls left at stall. Single-engine stalls were performed with the left engine at idle and the propeller windmilling. In all configurations the aircraft could not be stalled, since V_S was less than single-engine V_{MC}. This characteristic allows stall-free operation of the aircraft throughout the single-engine operational envelope. Recovery from the loss of control condition was easily accomplished by release of elevator control back pressure.

29. The aircraft artificial stall warning system operated at 26 to 30 knots above stall in the TO configuration, 17 to 25 knots above stall in the PA configuration, and 13 to 22 knots above stall in the L configuration. In all cases the stall warning airspeeds were greater than the maximum allowed in MIL-F-8785B(ASG). The premature activation of the artificial stall warning device of the RU-21H (GR V) aircraft is a shortcoming. Initial buffet ranged from 12 to 21 knots above stall at low engine power settings and zero to 5 knots above stall at high power settings in all configurations. During the tests, approximately 65 percent of the initial buffet airspeeds did not meet the criteria of MIL-F-8785B(ASG). Aircraft stall warning in the RU-21H (GR V) is not satisfactory. Consideration should be given to the installation of an angle-of-attack system in the RU-21H (GR V) aircraft which would present accurate stall airspeed cues in all flight conditions.

Table 9. Stall Airspeeds.

Configuration	Torque Left/Right (psi)	Average Gross Weight (lb)	Average Density Altitude (ft)	Center of Gravity (FS)	Stall Warning Indicated Airspeed (kt)	Buffet Indicated Airspeed (kt)	Stall Indicated Airspeed (kt)	Remarks
TO	100/100				101	92	71	
TO	600/600				94	70	68	
TO	1100/1100				92	68	63	
CR	600/600				96	75	67	
PA	100/100	9960	11,000	158.2 (aft)	91	81	66	1g stall
PA	600/600				82	61	59	
PA	1100/1100				78	59	55	
L	100/100				79	70	58	
L	600/600				71	55	52	
L	1100/1100				66	52	47	
TO	100/600				95	83	73	
TO	100/1100				98	83	72	
CR	100/600				102	80	72	
PA	100/600	9680	10,500	158.1 (aft)	87	70	63	Single-engine
PA	100/1100				83	74	65	
L	100/600				78	60	56	
L	100/1100				78	70	65	
TO	100/100				110	100	78	
TO	1100/1100				98	70	68	Accelerated stall, 30-deg bank (right)
PA	600/600	9460	10,500	158.1 (aft)	88	68	64	
PA	600/600				92	67	65	Accelerated stall, 30-deg bank (left)
L	100/100				88	77	73	Accelerated stall, 30-deg bank (right)
CR	100/100				102	92	73	
CR	600/600				95	70	69	
CR	1200/1200				90	65	65	
PA	100/100	9720	10,500	152.5 (fwd)	88	83	68	1g stall
PA	600/600				79	60	58	
PA	1200/1200				78	57	54	
PA	100/100	10,060	11,500	152.6 (fwd)	105	91	70	Accelerated stall, 30-deg bank (right)
CR	550/550	9080	23,500	151.8 (fwd)	---	75	73	1g stall
CR	550/550				93	75	72	

30. The artificial stall warning device is a horn which sounds in the cockpit. When conducting stalls at 22,000 feet Hp and wearing a helmet and oxygen mask the crew had difficulty hearing the horn. The inaudibility of the stall warning horn of the RU-21H (GR V) when the crew is wearing helmet and oxygen mask is a shortcoming. The artificial stall warning audio signal should be incorporated in the aircraft intercom system. As an interim measure the following WARNING should be placed in the appropriate section of the operator's manual.

WARNING

> The stall warning horn may be inaudible when wearing helmet and oxygen mask.

Trim Change Characteristics

31. The capability to trim the aircraft at all flight conditions was evaluated throughout this test program. The test conditions of table 2 were performed to evaluate aircraft trim response to a configuration change and data from this test are presented in table 10.

32. The aircraft was stabilized at the test configuration shown in table 10 and control forces were trimmed to zero. The trim was set to the recommended handbook setting for takeoff. Configuration change was then initiated and the resultant control forces estimated by the pilot. In the TO configuration, there was an initial pull force which changed to a steady-state push force at climb airspeed. The resultant control forces were excellent cues of the configuration change and were not obtrusive to the pilot. The pitch trim change control forces of the conditions tested (table 10) are within the guidelines of MIL-F-8785B(ASG), paragraph 3.6.3.1. Within the scope of this test the trim change characteristics of the RU-21H (GR V) aircraft are acceptable.

Trimmability

33. The longitudinal and directional (elevator and rudder) trim was effective at all airspeeds and configurations. The lateral (aileron) trim was ineffective in the CR configuration and at a low airspeed in the PA configuration. At CR airspeeds precise lateral trim was extremely difficult to achieve even in smooth air (HQRS 6). The ineffective lateral trim capability is a shortcoming.

COCKPIT EVALUATION

34. An evaluation of the RU-21H (GR V) cockpit was conducted throughout the flight evaluation. It included instrument and switch layout and readability, and both normal and emergency procedures. The evaluation was conducted during day and night lighting conditions.

Table 10. Trim Change Test Conditions.

Configuration	Density Altitude (ft)	Indicated Airspeed (kt)	Power Setting	Configuration Change	Parameter Held Constant	Elevator Control Force Change[1] (lb)
Note[2] TO	1500	120	TO	Landing gear up	Pitch attitude	±15
CR	11,200	170	PLF	Idle power	Altitude	±10
CR	11,200	170	PLF	Flaps to 35%		-10
	11,000	159	PLF	Landing gear down		+5
PA	11,200	120	PLF	Idle power		+5
PA	11,200	120	Idle	Max power		-5
Note[3] TO	2500	120	TO	Landing gear up	Pitch attitude	±15
CR	10,500	170	PLF	Idle power	Altitude	+15
CR	10,500	170	PLF	Flaps to 35%		-10
	10,500	159	PLF	Landing gear down		-5 to +10
PA	10,500	135	PLF	Idle power		+10
PA	10,500	120	Idle	Max power		-5

[1]Pull force is positive, push force is negative.
[2]Center of gravity: FS 157.4 (aft). Gross weight: 9000 pounds.
[3]Center of gravity: FS 152.5 (fwd). Gross weight: 9800 pounds.

35. The engine instruments are arranged vertically on the instrument panel, which facilitates rapid instrument cross-check and minimizes the pilot's scan time. The vertical display of the RU-21H (GR V) engine instruments is an enhancing feature which should be incorporated in all future designs. The cockpit of the RU-21H (GR V) is satisfactory, with the exceptions noted in the following paragraphs.

36. The RU-21H (GR V) has two annunciator panels (CAUTION and WARNING) installed in the cockpit. The WARNING panel is mounted in the center of the glare shield and the CAUTION panel is mounted in the bottom center of the instrument panel. The WARNING panel (red) illuminates when a hazardous condition exists and the CAUTION panel (yellow) illuminates for less serious faults. Each panel has its own master light. The arrangement and function of these two panels are excellent; however, the MASTER CAUTION and WARNING lights are too dim to be effective. The low intensity of the MASTER CAUTION and WARNING lights of the RU-21H (GR V) aircraft is a shortcoming.

37. The aircraft exterior lighting system was evaluated on the ground at night. The navigation lights mounted on the upper surface of the wing-tip pods created excessive glare in the cockpit. This glare was annoying and could adversely affect the pilot's ability to see and avoid traffic at night. The excessive glare caused by the navigation lights mounted on the upper surface of the external wing-tip pods is a shortcoming. The exterior lighting configuration should be further evaluated to include observation from a second aircraft at night to assure adequate visibility of the RU-21H (GR V).

38. The arrangement of the navigation and communications radios in the RU-21H (GR V) increased pilot workload during test flights. Their present locations are not conducive to efficient usage. The infrequently used ADF navigation radio occupies prime instrument panel space, while the high-usage VHF navigation radio is located on the control pedestal. The location of the much-used VHF communications radio requires the pilot to look down and aft to tune it, which is conducive to vertigo. The inefficient arrangement of the navigation and communications radios in the RU-21H (GR V) is a shortcoming.

39. The pilot and copilot attitude indicators present roll attitude information in opposite directions. On the pilot attitude indicator (ARU-13/A) the bank angle pointer and horizontal bar are slaved to the sphere and point to the left of the bank angle index in a right turn, whereas on the air-driven copilot attitude indicator the bank angle pointer and horizontal bar point to the right of the index in a right turn. The attitude indicator is one of the primary instruments used during instrument flight. Two instruments in the same cockpit which present opposite indications for the same maneuver are disconcerting and can produce disorientation. Specifically, during instrument flight conditions when aircraft control is passed from left to right or the pilots exchange seats, the initial reaction to the copilot indicator is to turn in the wrong direction. This could be critical during final approach under instrument flight conditions. The dissimilar sense of operation of the attitude indicators in the RU-21H (GR V) is a shortcoming and should be corrected when feasible.

40. The force required to operate the radio/intercom switches on the control yoke is excessive, resulting in thumb fatigue during prolonged use. This force was estimated at approximately 3 to 5 pounds. The excessive force required to operate the radio/intercom switches on the control yoke is a shortcoming.

41. With the engine power levers at the maximum power setting (full forward on the quadrant), neither engine could be shut down with its respective condition lever. This problem was caused by the movement of a bracket (item 90, figure 166, page 803 of TM 55-1510-209-23) under the cockpit floor. The bracket is of insufficient strength to prevent movement of the associated cables when the power levers are moved. With the power levers full forward on the quadrant, the bracket moved sufficiently to bind the condition lever cables and prevent engine shutdown with the condition levers. The binding of the condition lever cables with the power levers at maximum power setting is sufficient to prevent engine shutdown and is a shortcoming.

AIRSPEED CALIBRATION

42. An airspeed calibration was performed during this evaluation and is presented in figure 10, appendix D. It includes a comparison to the operator's manual airspeed correction data. This calibration shows that the external configuration changes of the RU-21H (GR V), including the flare/chaff dispensers, had a negligible effect on the airspeed system of the RU-21 aircraft and that the airspeed correction data presented in the operator's manual are adequate.

CONCLUSIONS

GENERAL

43. The RU-21H (GR V) aircraft handling qualities are similar to other U-21 aircraft and are acceptable. The vertical display of the engine instruments on the instrument panel is an enhancing feature which should be continued on future aircraft.

DEFICIENCIES

44. The following deficiency was identified: the values of V_{MC} presented in the operator's manual are incorrect (para 26).

SHORTCOMINGS

45. The following shortcomings were identified and are listed in order of importance:

a. The dissimilar sense of operation of the attitude indicators (para 39).

b. The excessive glare in the cockpit caused by the navigation lights mounted on the upper surface of the external wing-tip pods (para 37).

c. The inaudibility of the stall warning horn when the crew is wearing helmet and oxygen mask (para 30).

d. The low intensity of the MASTER CAUTION and MASTER WARNING lights (para 36).

e. The inefficient arrangement of the navigation and communications radios (para 38).

f. The premature activation of the artificial stall warning device (para 29).

g. The binding of the condition lever cables with the power lever at maximum power setting is sufficient to prevent engine shutdown (para 41).

h. The lightly damped easily excited phugoid characteristics (para 11).

i. The ineffective lateral trim capability (para 33).

j. The excessive force required to operate the radio/intercom switches on the control yoke (para 40).

RECOMMENDATIONS

46. The RU-21H (GR V) aircraft should be released for operational use within the limits of the operator's manual, following correction of the deficiency identified in paragraph 44.

47. The shortcomings listed in paragraph 45 should be corrected in future designs.

48. A single consolidated operator's manual should be issued for the RU-21H (GR V) in lieu of the two manuals which must be consulted at this time (para 6).

49. An autopilot should be concidered for future designs (para 11).

50. Add the following WARNING regarding V_{MC} to the operator's manual (para 26).

WARNING

> Aircraft control may be lost during an engine failure at airspeeds as much as 10 KIAS above those determined from the chart.

51. Conduct further testing to determine static and dynamic V_{MC} for the RU-21H (GR V) (para 26).

52. The installation of an angle-of-attack system which would present accurate stall warning airspeed cues in all flight conditions should be considered (para 29).

53. The artificial stall warning audio signal should be incorporated in the aircraft intercom system and/or the following WARNING should be added to the operator's manual (para 30).

WARNING

> The stall warning horn may be inaudible when wearing helmet and oxygen mask.

54. The exterior lighting configuration should be further evaluated (para 37).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, DRSAV-EQI, 4 May 1977, subject: Test Request for RU-21H Guard Rail V Preliminary Army Evaluation, Project No. 77-19.

2. Technical Manual, TM 55-1510-209-10-1, *Operator's Manual, RU-21A/D Aircraft,* 28 February 1977, with change 2, 15 February 1978.

3. Technical Manual, TM 55-1510-215-10-1, *Operator's Manual, Army Models RU-21E and RU-21H,* 31 March 1977 with change 2, 24 August 1977.

4. Letter, AVRADCOM, DRDAV-EQI, 30 September 1977, subject: Airworthiness Release for USAAVRADCOM/USAAEFA Project No. 77-19.

5. Military Specification, MIL-F-8785B(ASG), *Flying Qualities of Piloted Airplanes,* 7 August 1969, with Interim Amendment 1, 31 March 1971.

6. Flight Test Manual, Naval Air Test Center, FTM No. 103, *Fixed Wing Stability and Control,* 1 August 1969.

APPENDIX B. DESCRIPTION

GENERAL

1. The RU-21H (GR V) aircraft has the general structure of the RU-21A aircraft. Major modifications are listed below.

a. VHF high band dipole antennas removed from the 18-inch spanwise wing extension.

b. VHF low band dipole antennas removed from the fuselage.

c. Short blade dipole antennas installed on both wings, top and bottom surfaces, 225 inches from the buttline.

d. Guardrail I-type antennas (22-1/2-inch diameter by 102 inches long) installed on wing tips.

e. XM-130 fuselage flare/chaff dispenser module with aerodynamic fairing mounted on the aft upper surface of the right engine nacelle.

f. XM-130 aft nacelle flare/chaff dispenser module with aerodynamic fairing mounted on the right side of the fuselage.

2. A three-view drawing of the basic RU-21H (GR V) aircraft is shown in figure 1. Photos 1 through 4 provide a pictorial view of the aircraft modifications.

FLIGHT CONTROL SYSTEM

Primary Flight Controls

3. The RU-21H (GR V) aircraft is provided with a fully reversible flight control system with conventional dual controls for the pilot and copilot. Control wheels, interconnected by a T-column, and adjustable rudder pedals, interconnected by linkage below the floor, are linked to the control surfaces through a closed system of cables, bell cranks, and push-pull tubes. In addition to its conventional components, the control system for the elevators incorporates return springs. The elevators and rudder surfaces have balance horns incorporated in their design.

Secondary Flight Controls

4. Trim control for the rudder, aileron, and elevator is accomplished through a manually actuated cable drum system for each set of control surfaces. Trim tabs are located on each of the flight control surfaces and incorporate antiservo action on the ailerons and elevator. The rudder trim is adjustable left and right and maintains an "as adjusted" position throughout the full range of rudder deflection.

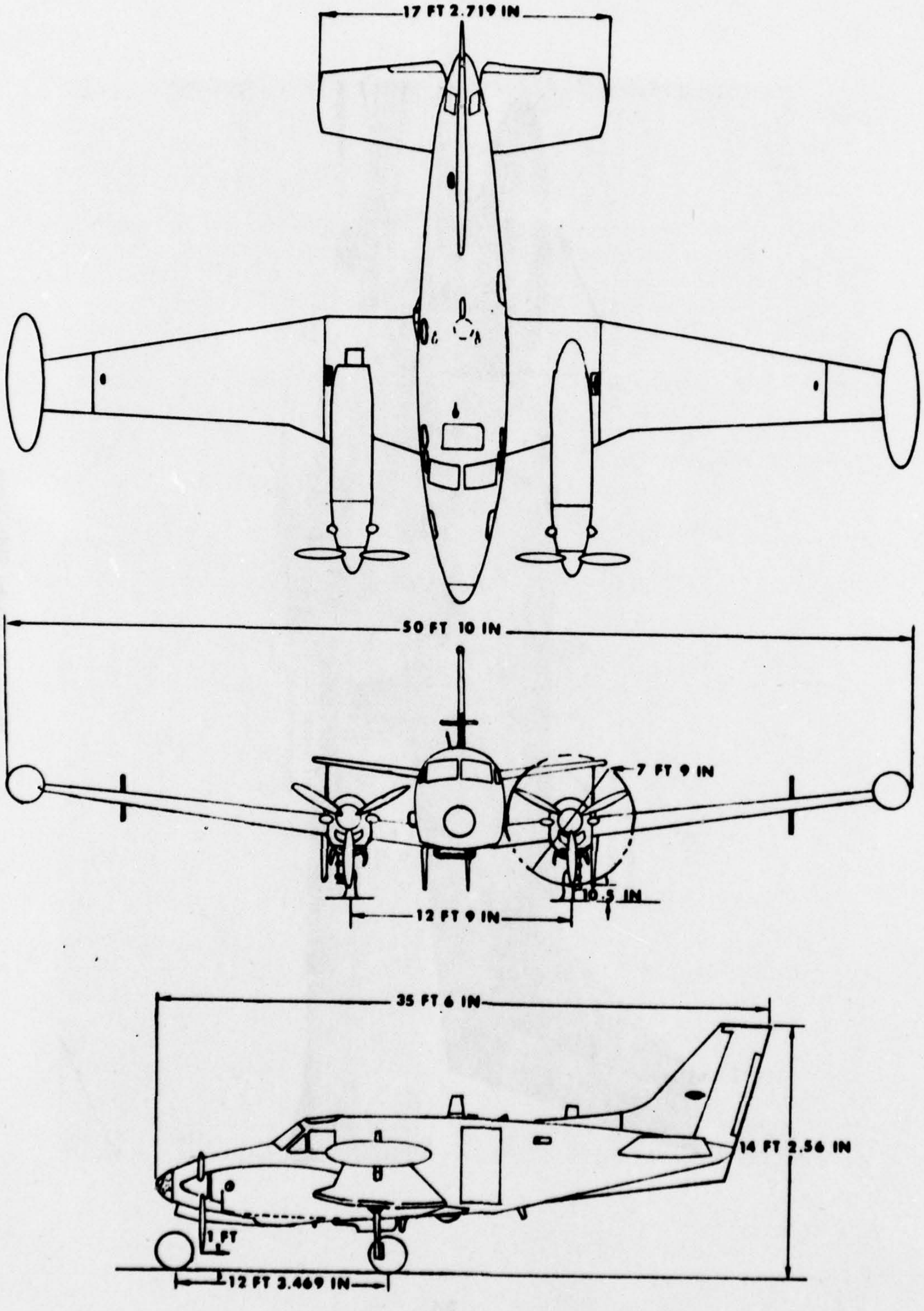


Figure 1. Three View Drawing, RU-21H Guardrail V Airplane

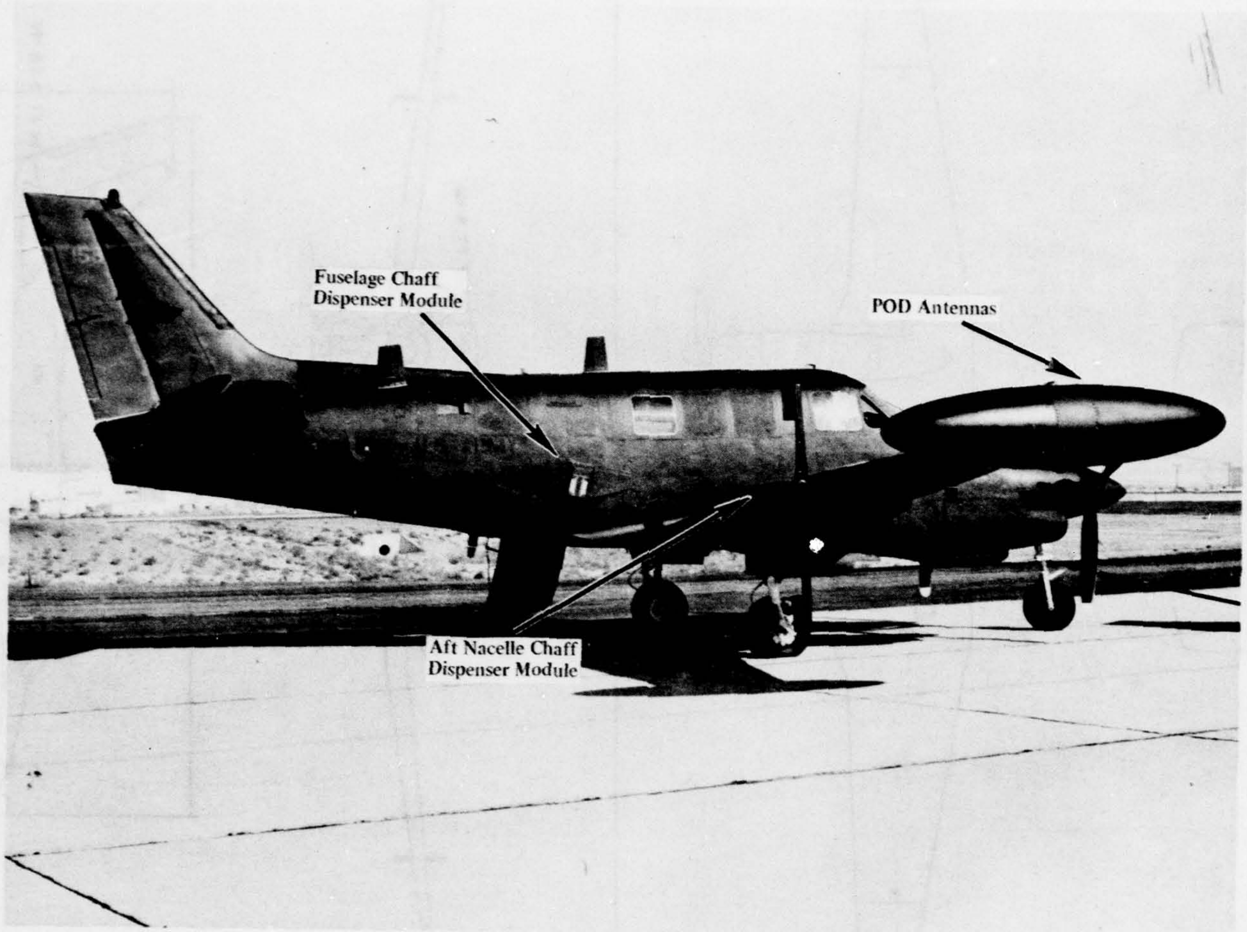


Photo 1. Right Side View.

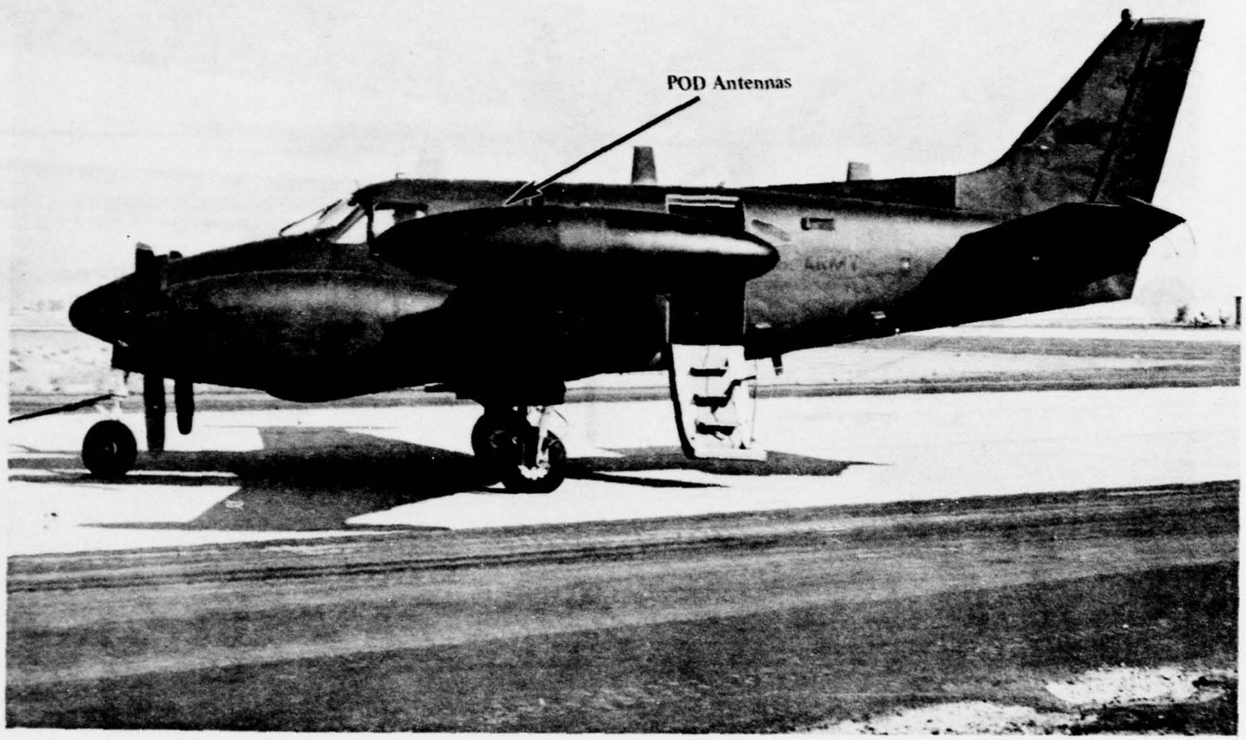


Photo 2. Left Side View.

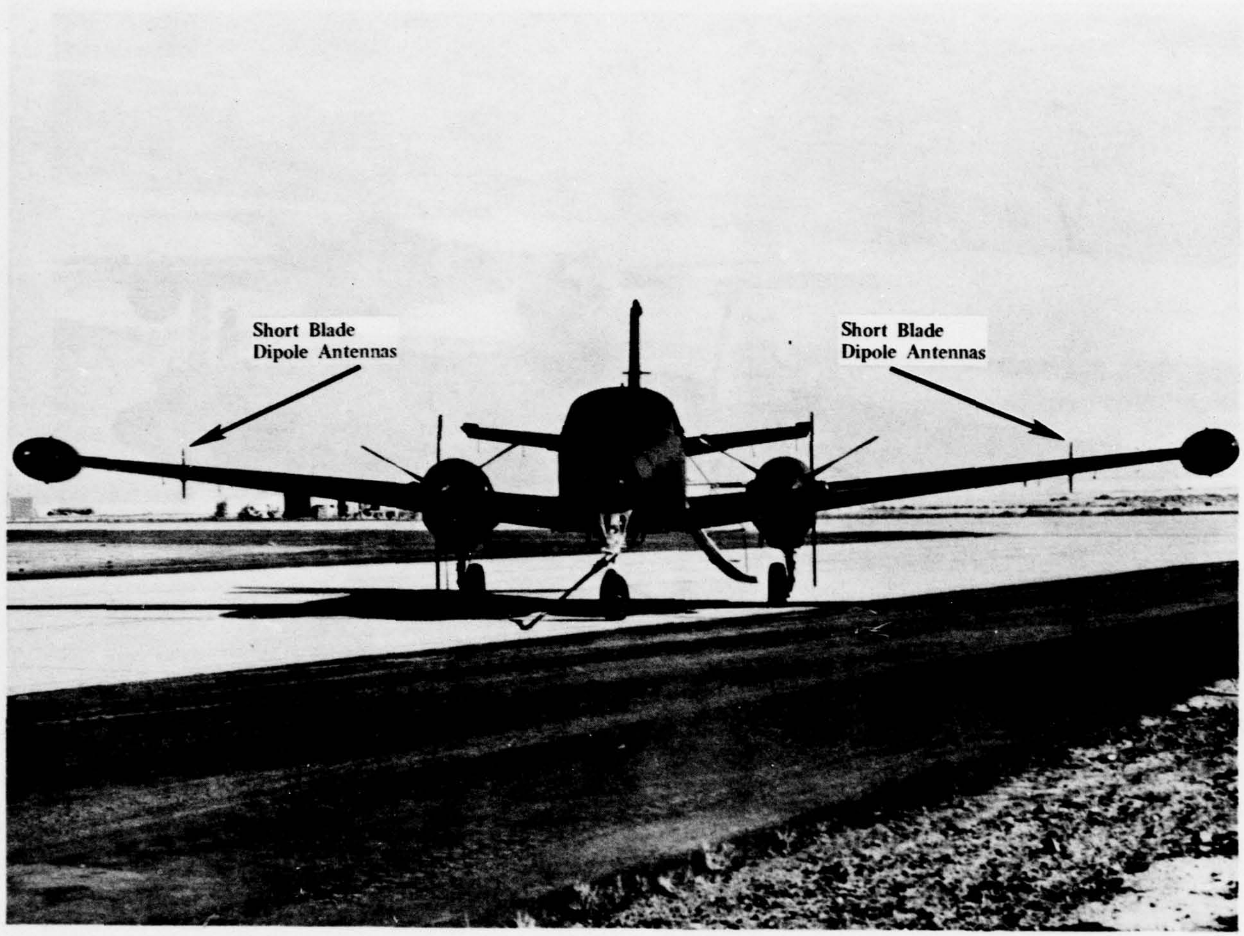


Photo 3. Front View.

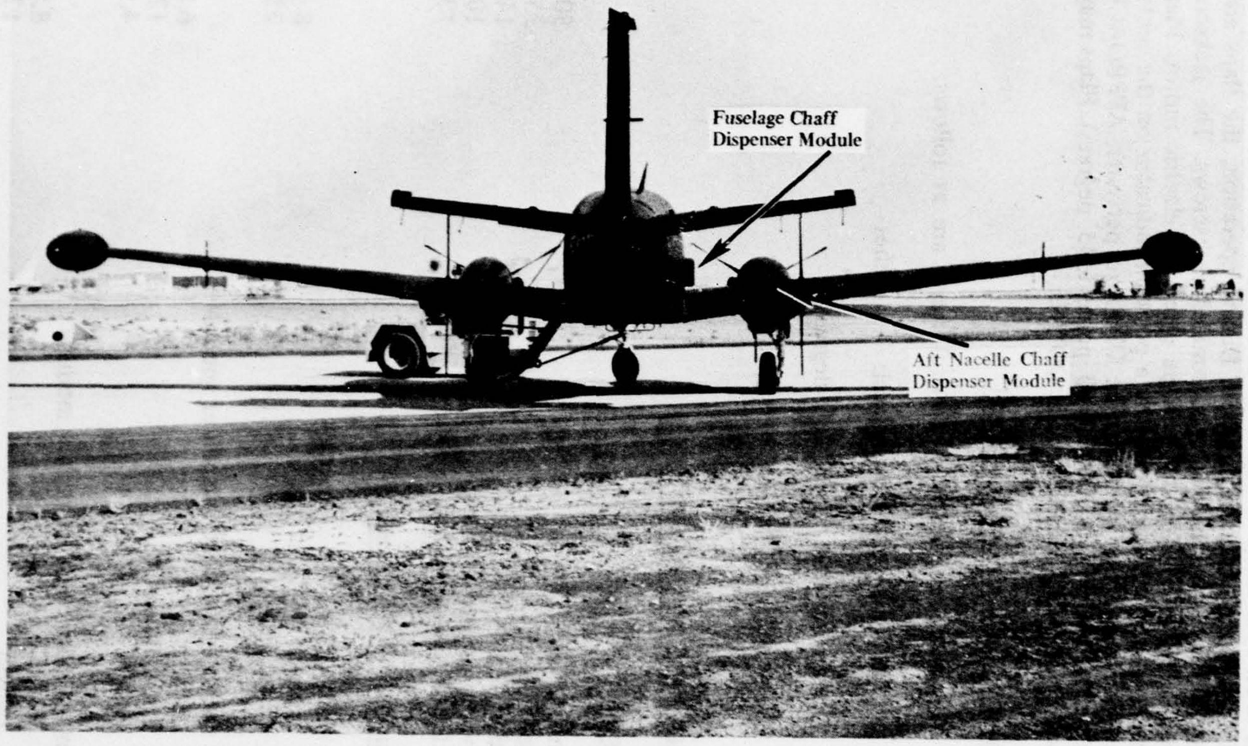


Photo 4. Rear View.

5. The all-metal, single-slotted flaps are electrically operated and consist of two sections on each wing. These sections extend from the inboard end of each aileron to the wing and fuselage juncture. During operation, the flaps are actuated as a single unit by separate but synchronized jackscrews. The jackscrews are driven through flexible shafting by a single reversible electric motor. Flap displacement is displayed in percent of travel by a position indicator on the center pilot control pedestal. Normal flap positions are UP (zero percent), APPROACH (35 percent, 15 degrees), and FULL DOWN (100 percent, 43 degrees). Flaps may be modulated between APPROACH and FULL DOWN.

<u>Maximum Cockpit Control Travel</u>

6. The maximum limits of control travel are as follows:

Rudder cockpit control travel: 7.3 inches

Aileron control travel: 200 degrees

Elevator control travel: 9.0 inches

AIRCRAFT DIMENSIONS

General

Span	50 ft, 10 in.
Length	35 ft, 6 in.
Height	14 ft, 2.56 in.
Propeller ground clearance	10.5 in.
Maximum take-off gross weight	10,200 lb

Guardrail V Modification

Tip pod:	
Length	8 ft, 6 in.
Diameter	22-1/2 in.
Aft nacelle flare/chaff dispenser module:	
Width	6.88 in.
Length	12.7 in.
Height	4.5 in.
Fuselage flare/chaff dispenser module:	
Width	8.88 in.
Length	12.7 in.
Height	4.5 in.

Short blade antennas:	
Length	**9 in.**
Depth	**4 in.**
Thickness	**0.55 in.**

APPENDIX C. INSTRUMENTATION

1. The test instrumentation on the RU-21H (GR V) aircraft, serial number 70-15887, consisted of the items listed below. Installation, calibration, and maintenance of test instrumentation was performed by either BAC or USAAEFA personnel as indicated.

Altimeter[1]	Pilot instrument panel
Sensitive airspeed indicator[1]	Pilot instrument panel
Sensitive g meter[2]	Pilot instrument panel
Aileron control position indicator[2]	Pilot yoke
Rudder control position indicator[2]	Copilot left rudder pedal
Elevator control position indicator[2]	Copilot yoke
Control force gage[2]	Hand-held by pilot
Stopwatch[2]	Hand-held by flight engineer
Yaw string (left and right)	Wing (left and right)
Fuel quantity gage[1]	Pilot left console
Inlet turbine temperature gage[1]	Pilot instrument panel
Propeller rpm gage[1]	Pilot instrument panel
Torque gage[1]	Pilot instrument panel

[1] Installed and calibrated by BAC.
[2] Installed and/or calibrated by USAAEFA personnel.

APPENDIX D. TEST DATA

INDEX

FIGURE 1
CONTROL POSITIONS IN TRIMMED FORWARD FLIGHT
RU-21H USA S/N 70-15887

AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	PROPELLER SPEED (RPM)	CONFIGURATION	FLIGHT CONDITION
9900	158.2(AFT)	10500	2.5	1900	CRUISE	LEVEL FLIGHT

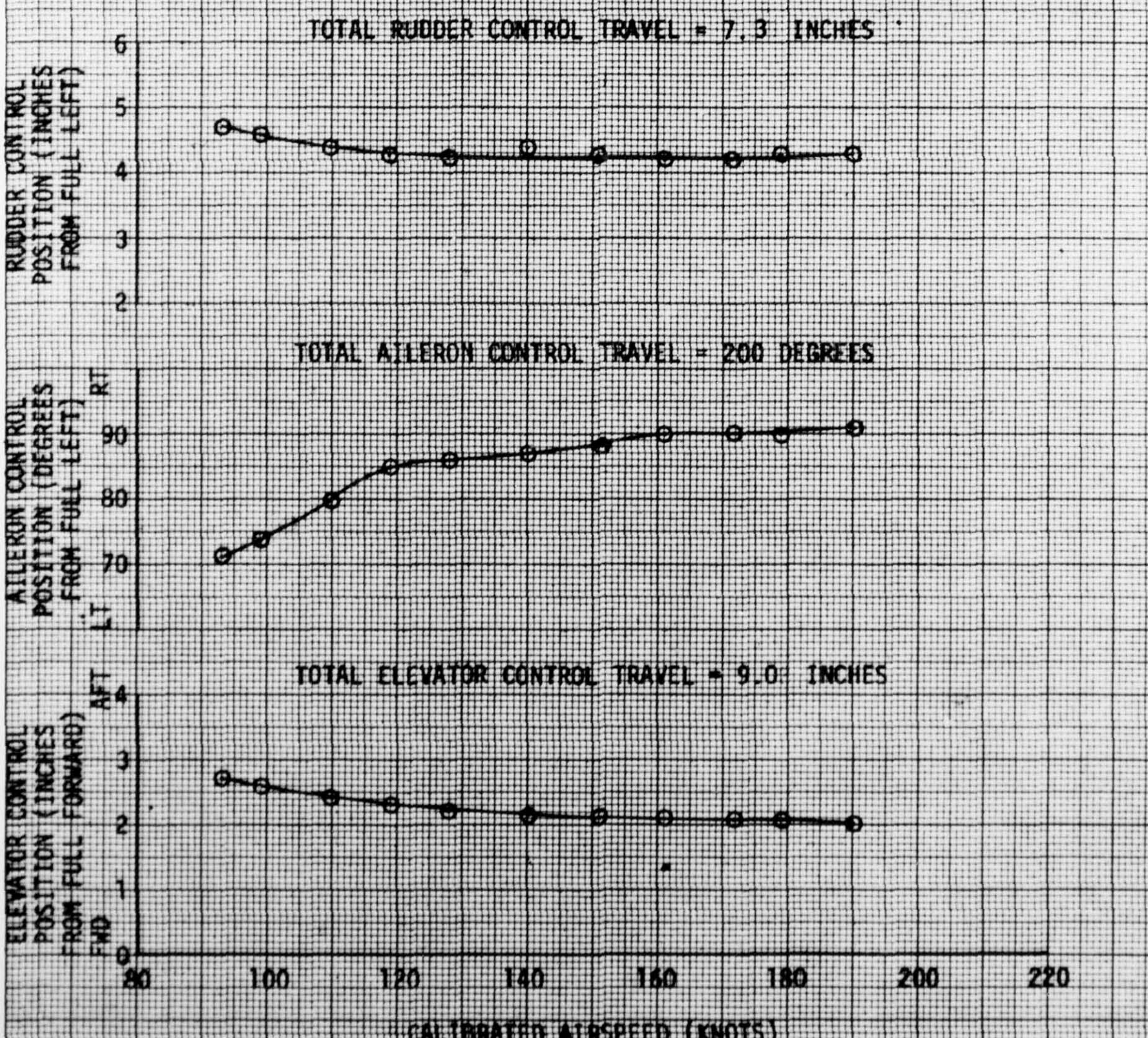


FIGURE 2
STATIC LONGITUDINAL STABILITY (AFT CG)
RU-21H USA S/N 70-15887

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	PROPELLER SPEED (RPM)	CONFIGURATION	FLIGHT CONDITION
○	9640	158.1(AFT)	10600	1.0	2000	POWER APPROACH	LEVEL FLIGHT
□	9740	158.1(AFT)	10400	4.0	1900	CRUISE	LEVEL FLIGHT
△	9460	158.1(AFT)	10100	6.0	1900	CRUISE	LEVEL FLIGHT

NOTE: SHADED SYMBOLS DENOTE TRIM

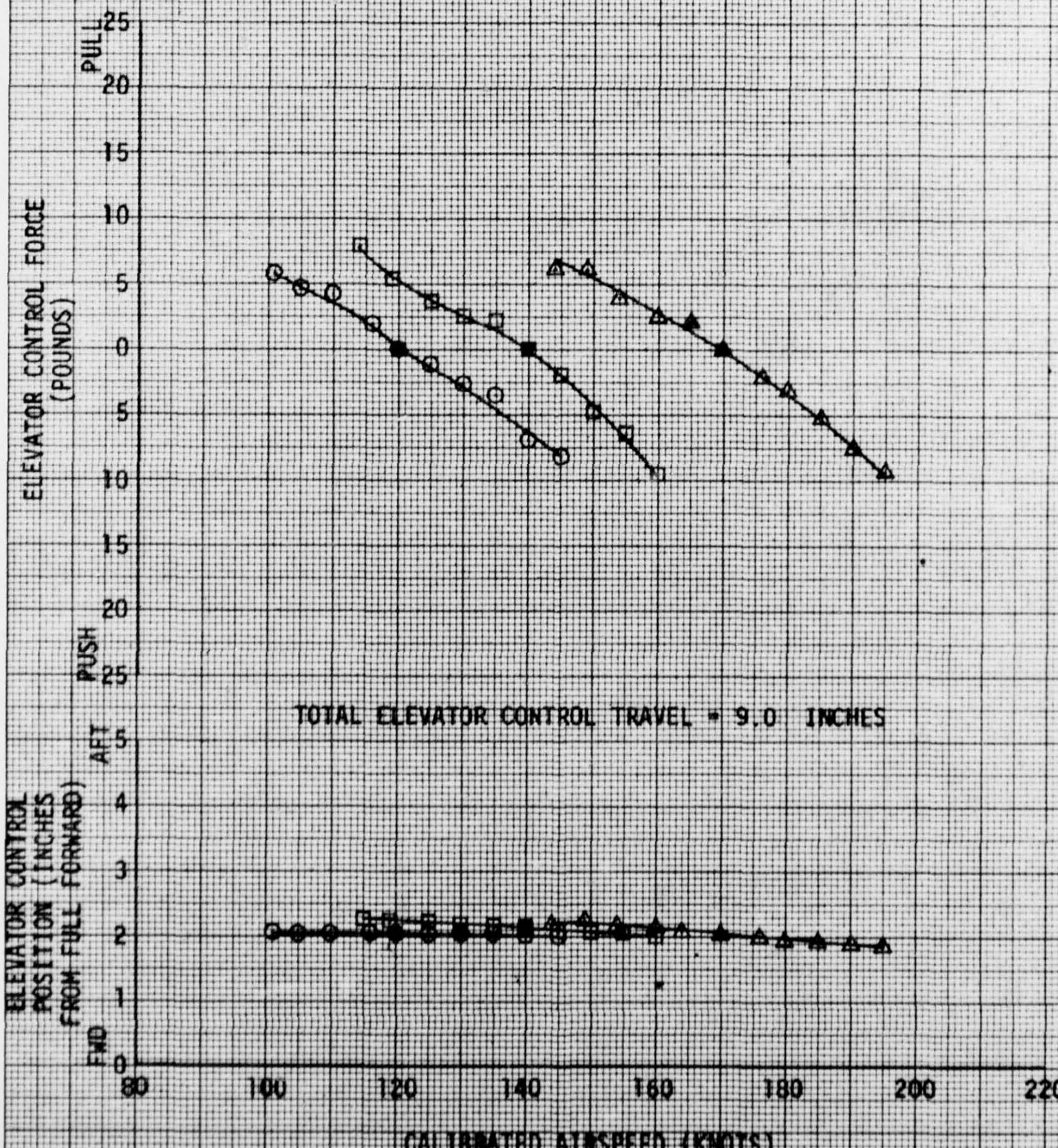


FIGURE 3
STATIC LONGITUDINAL STABILITY (FWD CG)
RU-21H USA S/N 70-15887

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	PROPELLER SPEED (RPM)	CONFIGURATION	FLIGHT CONDITION
○	9460	152.3(FWD)	10500	1.0	2000	POWER APPROACH	LEVEL FLIGHT
□	9300	152.2(FWD)	10400	-1.0	1900	CRUISE	LEVEL FLIGHT
△	9140	151.9(FWD)	10800	0.5	1900	CRUISE	LEVEL FLIGHT

NOTE: SHADED SYMBOLS DENOTE TRIM

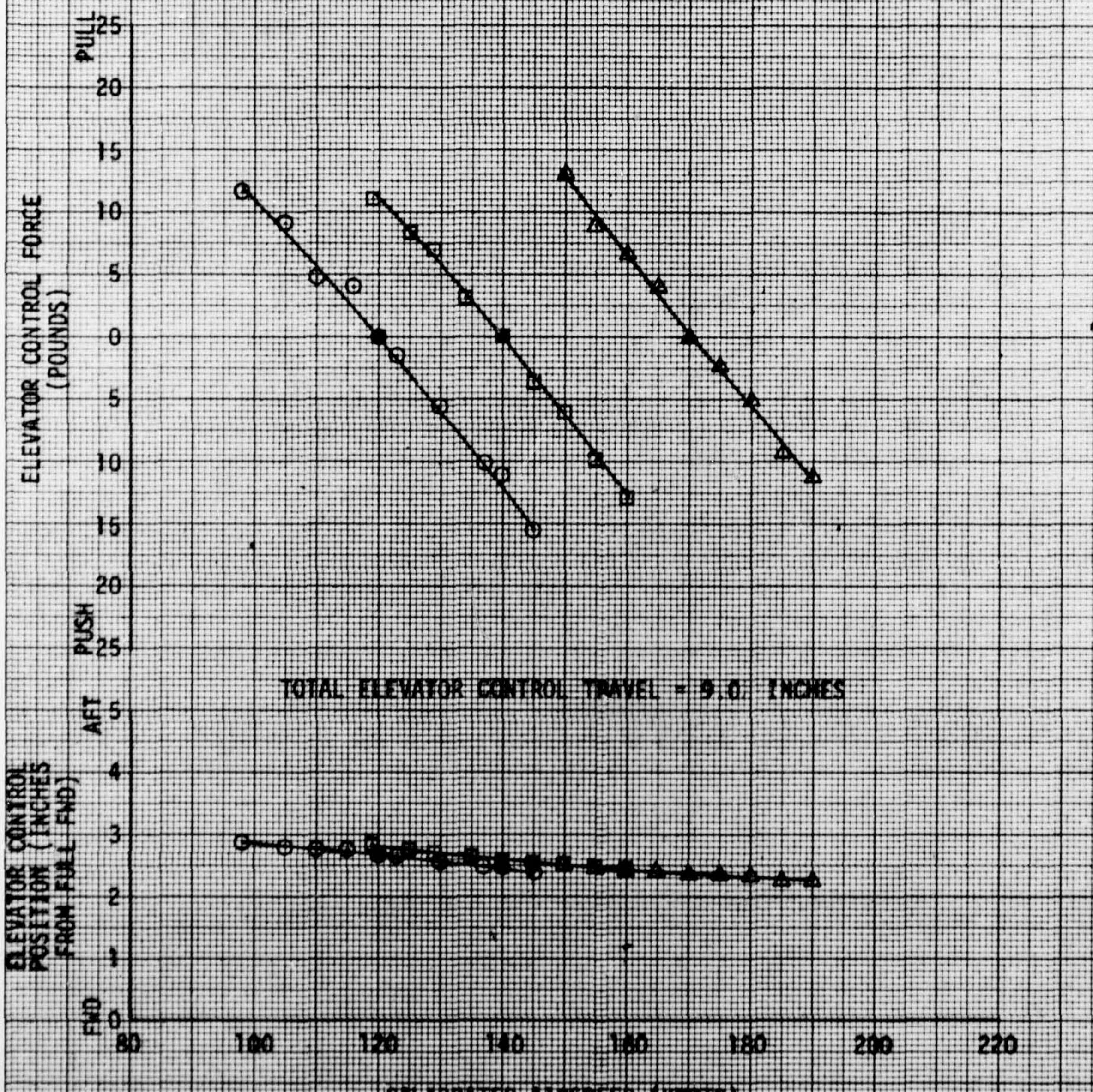


FIGURE 4
MANEUVERING STABILITY
RU-21H USA S/N 70-15887

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
○	9020	157.4(AFT)	11000	-2.0	120	2000	PA	RT TURN
□	9020	157.4(AFT)	11000	-1.0	121	2000	PA	LT TURN
◁	9020	157.4(AFT)	11000	-3.0	120	2000	PA	PUSH OVER
△	9020	157.4(AFT)	11000	-3.0	120	2000	PA	PULL UP

NOTE: SHADED SYMBOLS DENOTE TRIM

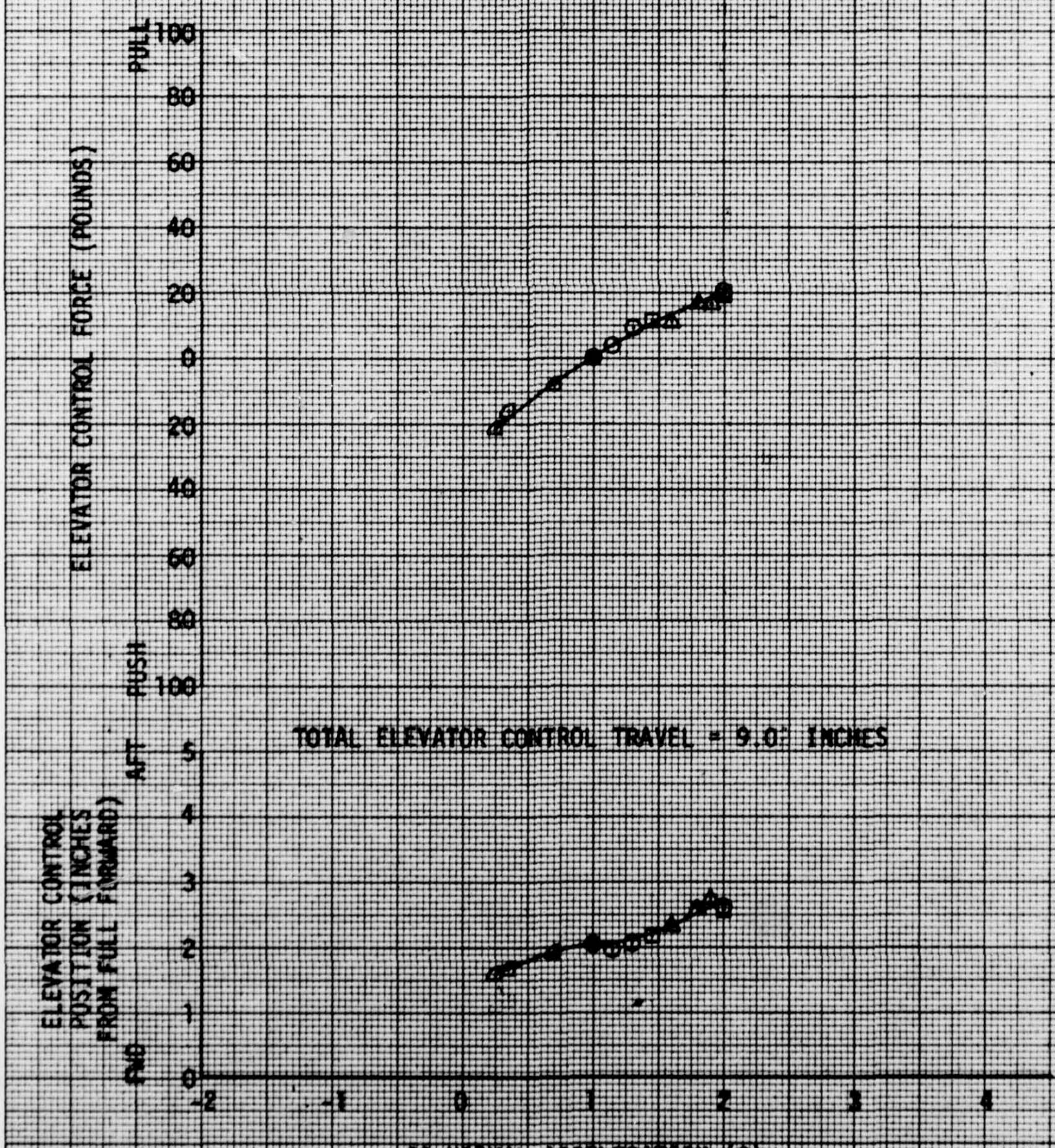


FIGURE 5
MANEUVERING STABILITY
RU-21H USA S/N 70-15887

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
○	9800	158.1(AFT)	10000	2.0	140	1900	CR	RT TURN
□	9000	157.3(AFT)	10600	3.0	139	1900	CR	LT TURN
△	9700	158.1(AFT)	10000	2.5	140	1900	CR	PULL UP
◁	9700	158.1(AFT)	9700	2.0	141	1900	CR	PUSH OVER

NOTE: SHADED SYMBOLS DENOTE TRIM

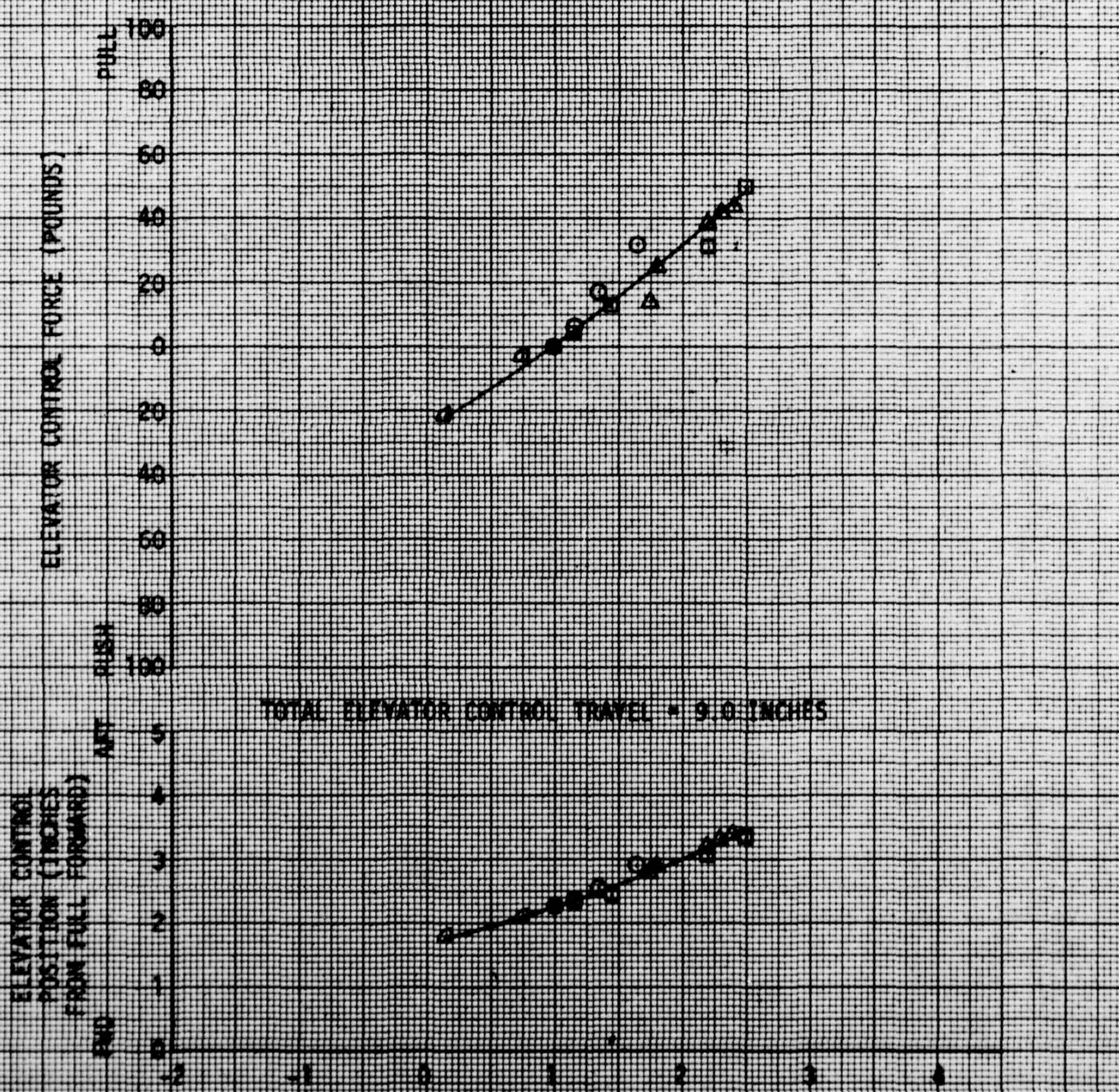


FIGURE 6
MANEUVERING STABILITY
RU-21H USA S/N 70-15887

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
○	9300	157.7(AFT)	10000	2.0	170	1900	CR	RT TURN
□	9250	157.7(AFT)	10000	2.0	170	1900	CR	LT TURN
△	9200	157.7(AFT)	9800	3.0	171	1900	CR	PULL UP
◁	9200	157.7(AFT)	10100	4.5	170	1900	CR	PUSH OVER

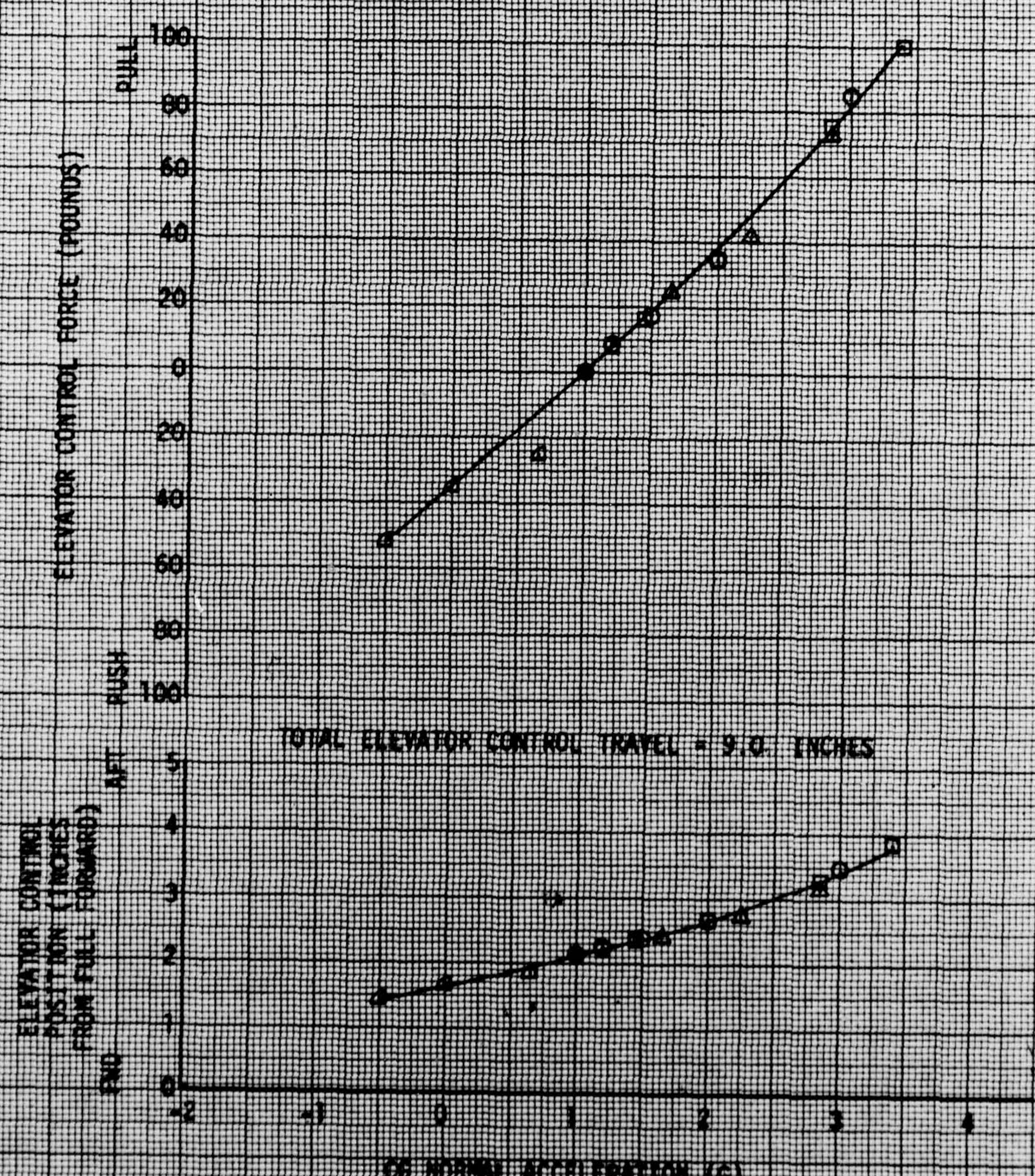


FIGURE 7
STATIC LATERAL-DIRECTIONAL STABILITY
RU-21H USA S/N 70-15887

AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
9400	157.9(AFT)	10200	2.0	120	2000	PA	DESCENT

NOTE: SHADED SYMBOLS DENOTE TRIM

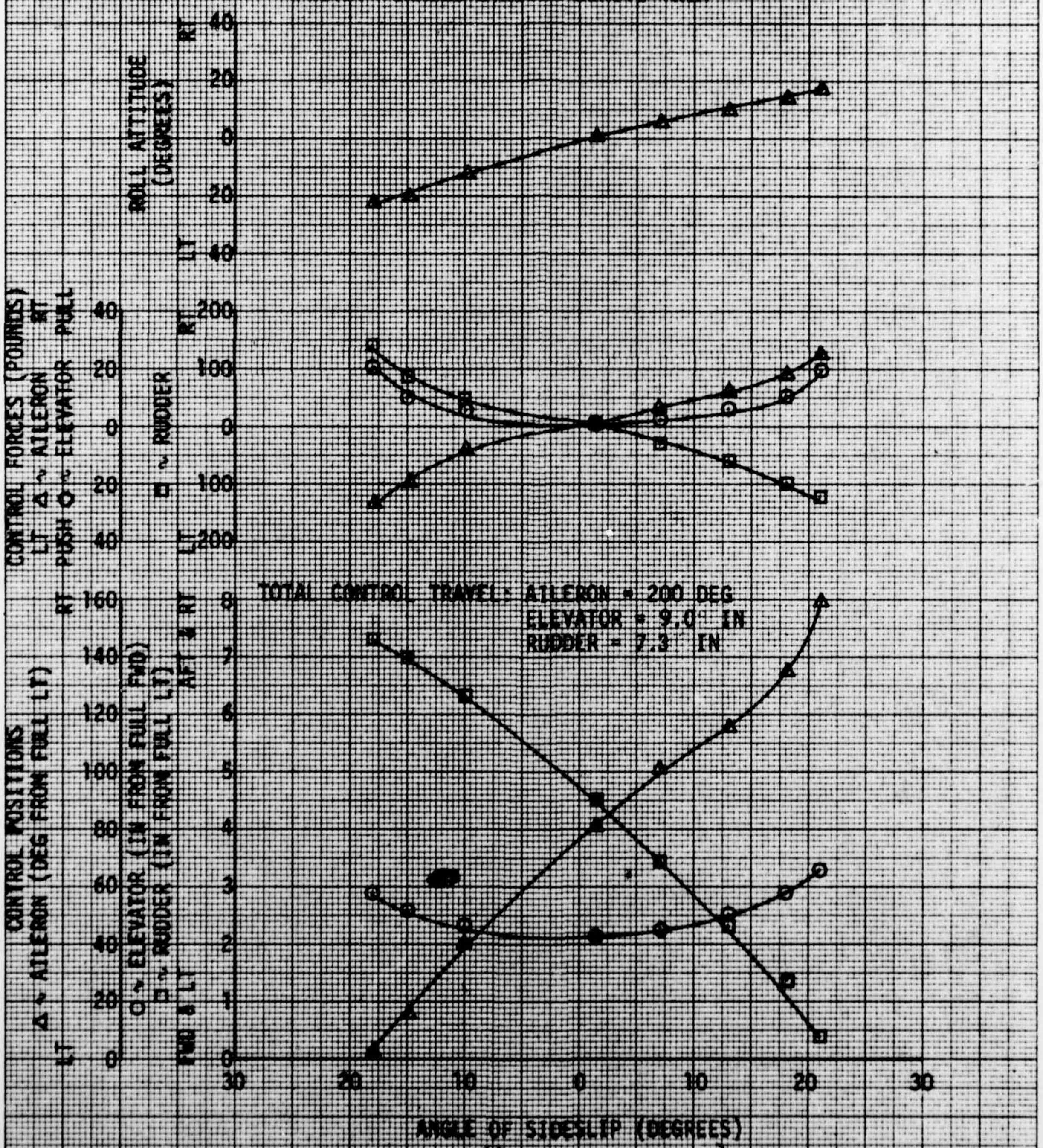


FIGURE 8
STATIC LATERAL-DIRECTIONAL STABILITY
RU-21H USA S/N 70-15887

AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
9190	157.6(AFT)	9500	7.0	140	1900	CR	LEVEL FLIGHT

NOTE: SHADED SYMBOLS DENOTE TRIM

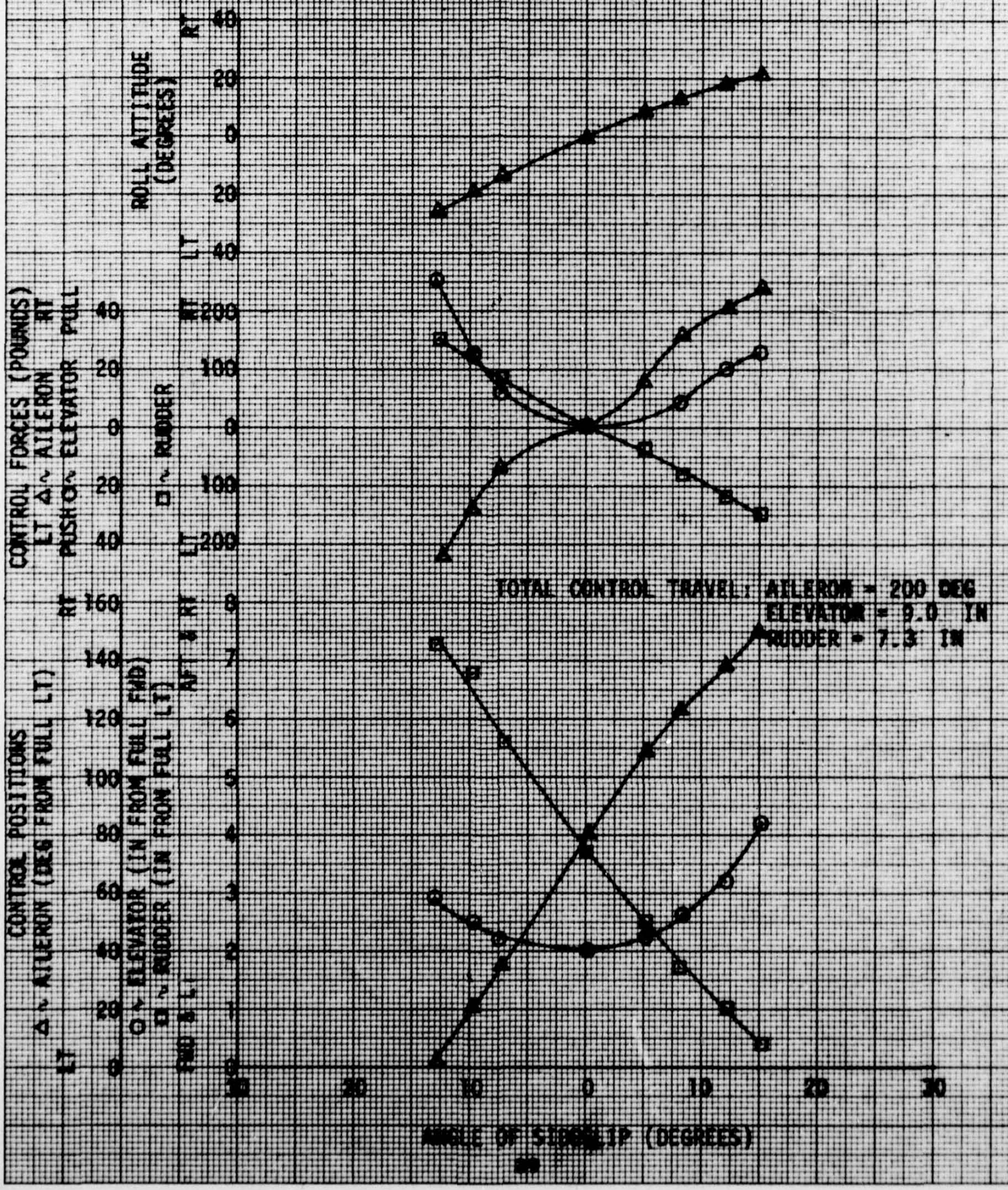


FIGURE 9.
STATIC LATERAL-DIRECTIONAL STABILITY
RU-21H USA S/N 70-15887

AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	TRIM AIRSPEED (KCAS)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
9620	158.1(AFT)	10100	4.0	170	1900	CR	LEVEL FLIGHT

NOTE: SHADED SYMBOLS DENOTE TRIM.

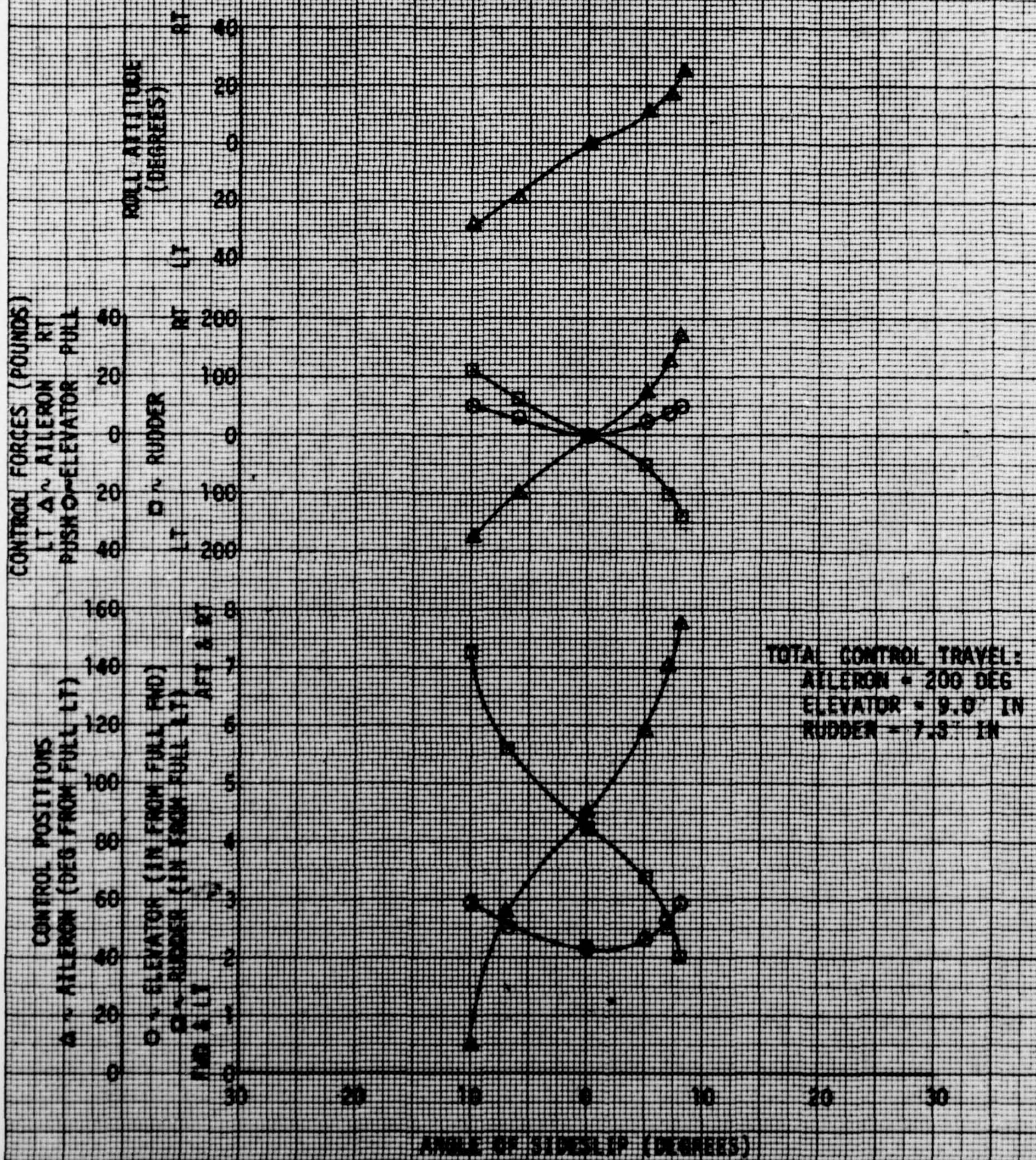
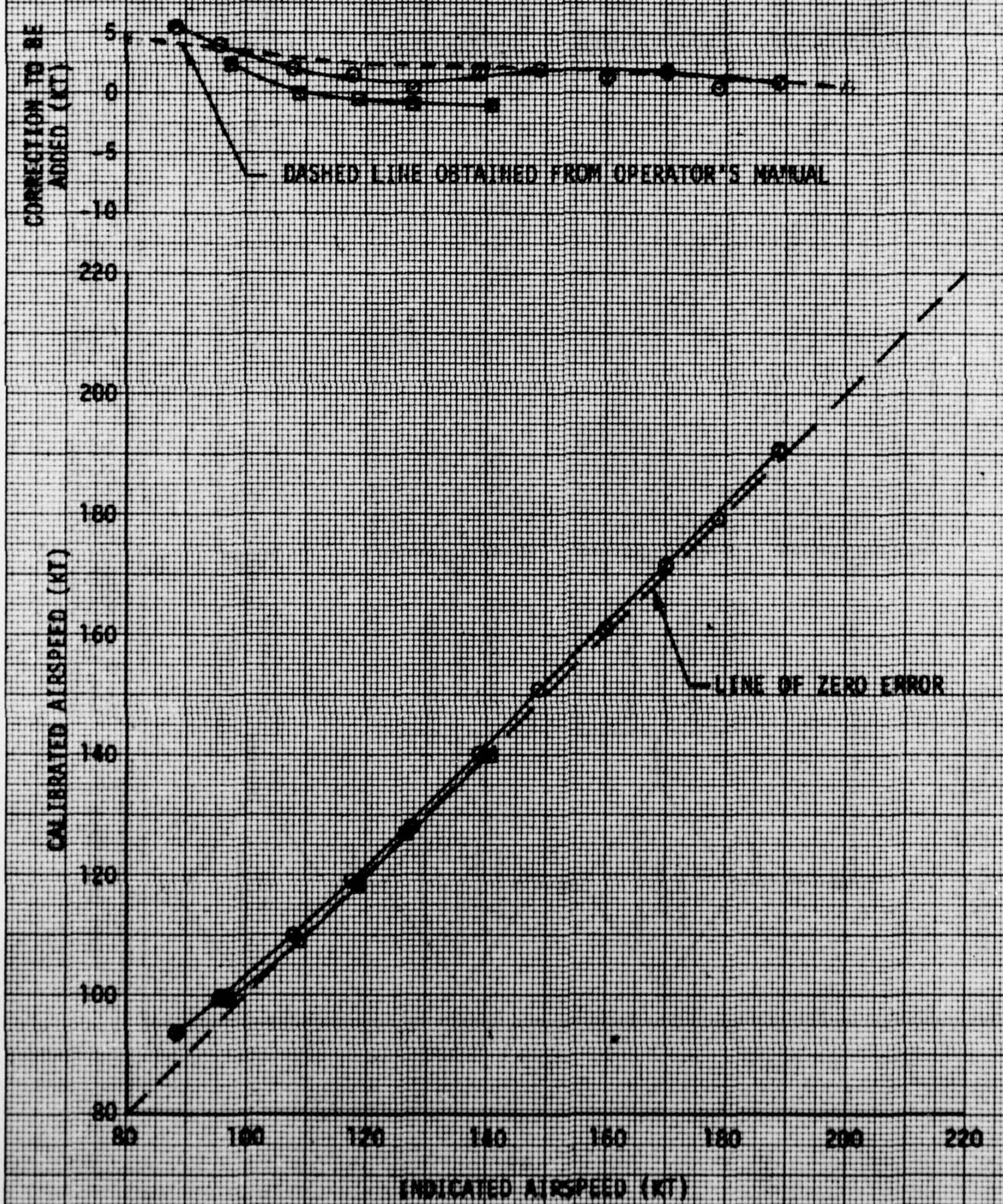
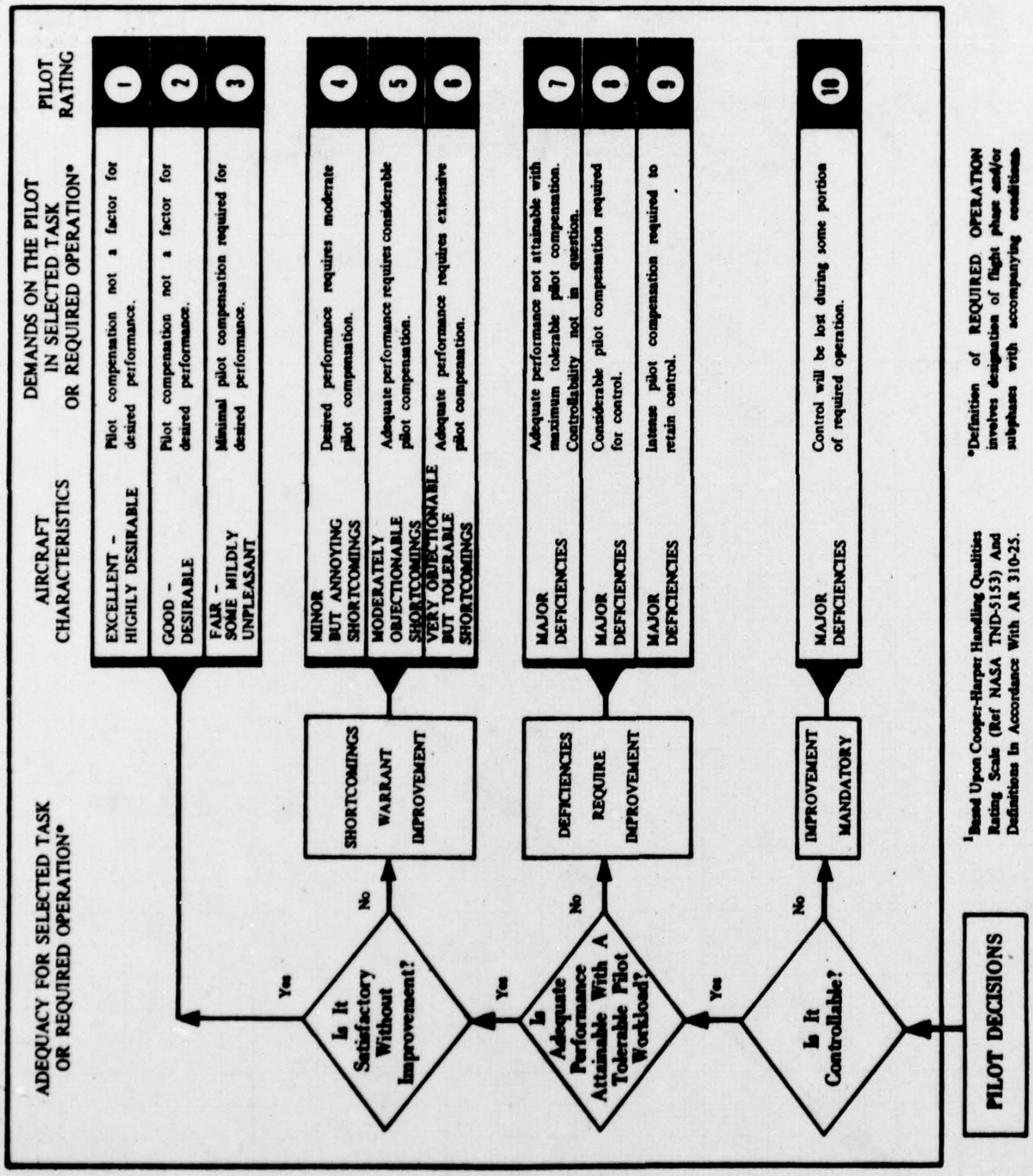


FIGURE 10
AIRSPEED CALIBRATION
RU-21H USA S/N 70-15887
SHIP SYSTEM ~ PACE METHOD

SYM	AVG GROSS WEIGHT (LB)	AVG LONG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FT)	AVG OAT (°C)	PROPELLER SPEED (RPM)	CONFIG	FLIGHT CONDITION
○	9000	158.2(AFT)	10500	2.5	1900	CR	LEVEL FLIGHT
⊟	8700	158.2(AFT)	11000	2.0	2000	PA	LEVEL FLIGHT



APPENDIX E. HANDLING QUALITIES RATING SCALE



*Definition of REQUIRED OPERATION involves designation of flight phase and/or subphases with accompanying conditions.

[1]Based Upon Cooper-Harper Handling Qualities Rating Scale (Ref NASA TND-5153) And Definitions In Accordance With AR 310-25.

DISTRIBUTION

Director of Defense Research and Engineering	2
Deputy Director of Test and Evaluation, OSD (OAD(SSST&E))	1
Assistant Secretary of the Army (R&D), Deputy for Aviation	1
Deputy Chief of Staff for Research, Development, and Acquisition (DAMA-WSA, DAMA-RA, DAMA-PPM-T)	4
US Army Materiel Development and Readiness Command (DRCDE-DW-A, DRCSF-A, DRCQA, DRCPM-AE)	7
US Army Aviation Research and Development Command (DRDAV-EQ)	12
US Army Training and Doctrine Command (ATCD-CM-C)	1
US Army Materiel Systems Analysis Activity (DRXSY-CM)	2
US Army Test and Evaluation Command (DRSTE-AV, USMC LnO)	3
US Army Electronics Research & Development (AMSEL-VL-D)	1
US Army Forces Command (AFOP-AV)	1
US Army Armament Command (SARRI-LW)	2
US Army Missile Command (DRSMI-QT)	1
Director, Research & Technology Laboratories/Ames	2
Research & Technology Laboratory/Aeromechanics	2
Research & Technology Laboratory/Propulsion	2
Research & Technology Laboratory/Structures	2
US Army Air Mobility Laboratory, Applied Technology Lab	1
US Army Human Engineering Laboratory (DRXHE-HE)	1
US Army Aeromedical Research Laboratory	1
US Army Infantry School (ATSH-TSM-BH)	1
US Army Aviation Center (ATZQ-D-MT)	3
US Army Aviation Test Board (ATZQ-OT-C)	2
US Army Aviation School (ATZQ-AS, ATST-CTD-DPS)	3
US Army Aircraft Development Test Activity (PROV) (STEBG-CO-T, STEBG-PO, STEBG-MT)	5
US Army Agency for Aviation Safety (IGAR-TA, IGAR-Library)	2
US Army Maintenance Management Center (DRXMD-EA)	1
US Army Transportation School (ATSP-CD-MS)	1
US Army Logistics Management Center	1
US Army Foreign Science and Technology Center (AMXST-WS4)	1

US Military Academy	3
US Marine Corps Development and Education Command	2
US Naval Air Test Center	1
US Air Force Aeronautical Division (ASD-ENFTA)	1
US Air Force Flight Dynamics Laboratory (TST/Library)	1
US Air Force Flight Test Center (SSD/Technical Library, DOEE)	3
US Air Force Electronic Warfare Center (SURP)	1
Department of Transportation Library	1
Beech Aircraft Corporation	5
Defense Documentation Center	12